HANDBOOK

OF

CONSTRUCTION PLANT

Its Cost and Efficiency

BY

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PREFACE TO THE FIRST EDITION.

It has been a considerable time since my office commenced to gather the data that have been collated for this book, and during all of that period the manuscript sheets, and later the page proofs bound up for convenient handling, have been in almost daily use. Consequently many of the items have been used and verified; so that I have rather more confidence in the usefulness as well as the general accuracy of the material than if it had not passed through a fairly thorough period of seasoning. This time of seasoning has its disadvantages, however, as well as its benefits. Changing conditions in certain industries have affected prices, and a number of items have been radically revised in the making. It is to be expected, moreover, that the same thing will continue; and as I have said in the introduction, page 3, these figures should be checked by actual bids where a plant is to be appraised, etc. In order to facilitate this, lists of the principal manufacturers of the plant described are given.

My principal reason for thinking that these notes would be useful to others is that I found them all but indispensable in my own practice, and not available in other form. My justification for the alphabetical method of classification is that this scheme admits of more rapid service on my desk than any other and I have attempted to supplement this arrangement by a very full index. For encouragement in this plan of procedure I am indebted to many of my engineering friends, who have aided by suggestions and useful criticisms.

Finally, the keynote of the book has been practical utility to the man who has to buy, sell or use construction plant, or who needs to know what can be done with it. The existing facts in the shortest time on the reader's part, rather than interesting theory and clever comparisons have been kept most in mind. Because of this, a large wealth of material that would probably be of intense interest to the economist and the engineering student has been put aside for publication some time later if it seem desirable, but for which there is no space in this volume, which has grown to just double the size originally planned for it.

A more general idea of the scope of the work, its field and its limitations may be found in the introductory chapter which follows this preface.

RICHARD T. DANA.

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INTRODUCTION

The notes that I had on the elements which go to make up equipment charges on construction work were so often on my desk, and so necessary, in view of the scarcity of other convenient sources of the information, that it was decided to complete them as far as might be practicable and publish them in this form for the benefit of other engineers who are obliged to make many estimates of construction cost.

The efficiency of equipment is increasing much faster than the efficiency of labor, consequently the employment of equipment is becoming more and more necessary for economical operation, and a fairly comprehensive list of the available plant with its approximate cost is now essential to a fair estimate. The material covered in this volume comprises the larger part of the contents of four loose leaf books that form the Construction Service Company's file on "Plant."

For his excellent work in arranging the data and in obtaining a great many quotations to round out the material that was in the file, as well as for many contributions from his own notes, my sincerest acknowledgements are due to my Principal Assistant, Mr. Harold Chandos Lyons, who was materially helped by Mr. A. C. Haskell, to whom we owe many of the tables and extensive checking of the text.

The problem of how to carry out a given plan of construction at the lowest cost is year by year becoming more complex, and it is becoming more and more necessary to apply to it scientific methods in order to meet the growing competition between various men, methods, and machines. The contractor of long experience who applies to his work, even in its simplest operations such as moving earth by scrapers, the methods that he knows absolutely were the best ten years ago, is competing, whether he knows it or not, with men who have developed up-to-date methods that are very likely to be twenty, thirty, or even forty per cent more efficacious or economical than the best old ones.

It is of vast importance to know the relative costs of different methods, some of the reasons for which it seems worth while to outline here. Before bidding on new work, it is generally not

difficult to find out what methods the other bidders are accustomed to, and, by making independent estimates based on the probable methods for the most dangerous competitor, to reach a figure that is something better than a mere guess at what his bid may be. Of course, it must be distinctly understood that this is not an attempt to eliminate human nature from the contracting business. The "most dangerous competitor" may suddenly change his methods and upset a lot of calculations, and whether he will do this or not is just as much a matter for psychologic study as what sort of hand he is drawing to when he takes one card. Nevertheless the man who knows his competitor's usual methods, and knows the relative efficiency of those methods as compared with his own, is in a position to bid much more intelligibly than he otherwise could. With the increasing disuse of old methods it is necessary to know the value of the new ones in order to know whether it will pay to change from old equipment to new, and how much (if anything) the change may be expected to save; and it is vastly important to know what is the very best method for the work to be done. Even if a contract can be carried out at a handsome profit by the second best or third best method, the man is a fool who would hesitate to discover and apply the first best, thus converting a handsome profit into a still handsomer one. When, moreover, a loss is being faced, it is almost always due, according to my experience, to the fact that the wrong methods were in use, rather than that the contract had been taken at "impossible figures." In such a situation the first and most necessary move is to ascertain the very best method and apply it immediately; and to assist the contractor and the engineer in the selection and application of the best method in the least time is the main object of this volume, which is devoted to Field Equipment.

It is a fact of common experience that if we want, or think that we may want, a piece of equipment for certain work, we can have a large amount of free literature upon the subject, backed up by the extensive experience and earnest enthusiasm of the salesmen of equipment houses. Such information is not always reliable and it is generally confusing. Moreover, before it can be applied to the work in hand it must be sorted, collated, studied and verified, a process requiring a ruinous amount of time for every investigation. This book attempts to save the estimator and contractor a large part of this time, which is ordinarily lost. The author has never sold any kind of equipment on commission and has never received a commission of any kind for recommending the adoption of any machine or tools for any purpose, and has no interest whatever in any statement contained in this book except to see that it correctly represents the economic facts in a useful and convenient way. Although it has been carefully checked for errors, it is possible, of course, that mistakes may have escaped notice. If any such should be noted, a memorandum, mentioning page-number and line would be greatly appreciated.

The main features of equipment which bear upon economic operation are as follows:

C Cost, ready to commence work.

Q Capacity, minimum, standard and maximum.

E Operating expense, including depreciation and repairs.

A Adaptability to the conditions governing the work.

No effort has been spared in preparing this volume to put the information into such form as to make it available, with the minimum of time and trouble, and it is believed that with the aid of the information contained in these pages an intelligent estimator of practical experience can determine within reasonable limits the figures for each of the above features. Prices vary from year to year, and terms of sale change with the conditions; but within a limit too small to affect materially an estimate of unit cost for plant performance, I believe the facts here given may be safely used. For making appraisal of a plant to be sold, if these figures be used they should of course be checked by actual bids from the manufacturers or dealers to the appraiser. In nearly every instance the prices here given represent bona fide quotations made to the author, but since the book is not written to advertise anyone no names are given.

Except where otherwise expressly stated the prices are f. o. b. the manufacturer's works.

(C) The cost, ready to commence work, includes

(p) the purchase price, the

(t) cost of transportation, and the

(a) preparatory cost, including unloading, erecting and getting into working position.

When possible the shipping weights have been included here, and the freight rate may be obtained from the nearest railroad agent, usually on the telephone. Data on the cost of erecting and installing machinery are not very plentiful. I have included them wherever possible from the available information.

(Q) The capacity of equipment is a very elusive quantity. That of a wagon, ship, bucket or scraper is usually listed by the manufacturer as the "water measure" capacity and must be corrected to obtain the "place measure" capacity. The capacity of a steam shovel in theory is the "water measure" of the bucket multiplied by the rated number of swings per unit of time; in practice it is likely to average from 20% to 70% of this, with the odds on the lower figure. Therefore the capacity figures must be taken as purely relative for the purpose of defining the size or type of equipment mentioned. A good many elements enter into this, not the least of which is often the skill of the operator. A steam shovel, in particular, is dependent for its capacity upon the skill of the runner and the manner in which the runner and craneman work together. The character and condition of the material that is handled may greatly affect the performance, so that capacity under ideal conditions (which is the manufacturer's assumption when rating his machines) is simply the maximum, and is rarely to be equaled in working practice. Moreover, the capacity of such a machine as a steam

shovel is limited by that of the cars into which it is loading, and is affected by the necessity of "moving up," and of changing trains, etc.

(E) The cost of operating a machine depends a good deal on the skill of the operator, as well as on the layout of the work, weather conditions, etc. In estimating this quantity, there should be included the incidental and necessary costs without which it cannot work to advantage. The cost of operating a hoisting engine, for example, includes that of coal "on the platform," which may include the cost of hauling coal from a delivery point, and should include the cost of coaling at night, watchman's time, etc. The operating cost and operating capacity are reciprocally dependent on each other.

(A) The adaptability of a particular machine to the conditions governing its work is often, if not always, the most important feature to be considered in its selection, since on this feature its practical efficiency for the work in hand largely depends. Adaptability is affected by the peculiarities of the work on which it is to be employed as well as those of the machine itself, and for a proper judgment as to its value an intimate knowledge of the machine and a thorough knowledge of the conditions under which it is to work are necessary. Unfortunately the working conditions are not always ascertainable with sufficient exactness to be sure of selecting the most suitable plant, and, more unfortunately, reliable information about new equipment is scarce. Salesmen, while probably no worse than the rest of mankind, are always biased by their personal interest in the product that they handle, and they cannot be expected to give due weight to the faults of their own machines or the virtues of those sold by their competitors, and are poor advisers in consequence. Theoretically, a way to avoid this disadvantage would be to call in rival salesmen and let them talk out the whole subject in the presence of each other. The writer tried this plan just once, at the request of a client, and it was a howling failure. Advertising statements, while honestly meant, are apt to be outrageously deceptive. As an instance of this the following was cut out of one of the technical journals.

"DUMP WAGON COSTS

"Eight men can shovel one cubic yard of loose sandy loam into a dump wagon in 3 minutes, therefore, in a 10-hour day these 8 men could load 200 cubic yards of material. At $1.50 per day, 8 men cost $12.00; therefore, the labor cost alone on 200 yards would be 6 cts. per cubic yard.

"OUR COSTS

"This cubic yard machine is loaded in ¼ minute; therefore, in a 10-hour day one man on this machine can load 2,400 cubic yards of material, or 12 times as much as 8 of your competitors' men can shovel in a 10-hour day.

"On the above basis we figure the two teams and their drivers, and even then taking this cost at $10.00, the cost per cubic would be .004, or four mills.

"There are a number of items and incidentals yet to be added to both of these costs but the ratio of cost is as 1 to 21 in favor of this scraper."

This is cost analysis gone mad with a vengeance, yet the man who wrote it in all probability thought that he was highly conservative. A great many manufacturers use special care that the statements in their trade literature shall be undeniably on the safe side on account of the very bad moral effect of an exaggeration. One of the large manufacturers of electrical machinery has been known to permit salesmen to state as the working efficiency of certain machines a percentage of the results shown by mechanical tests, on the ground that a disappointed and disgusted customer is the worst advertisement possible. Notwithstanding this fact, there are many machines that would be much more generally used did contractors feel confidence in the statements regarding them. The old and tried machine that is not especially well adapted to the work in hand is thus often used for lack of reliable information about the new and unknown one.

No book can tell a contractor automatically what equipment is the best for his use, but it is possible to put him in possession of vastly more information than has heretofore been available, and this has been attempted in the present volume.

The object of this book being primarily to furnish the information needed by contractors, and the material having become rather voluminous, it was thought advisable to leave out a great many items which might be useful to a very few contractors, but which would not be generally employed by the vast majority of them. The author will appreciate hearing from contractors who would like to find more material than obtained in the book, with a view to finding out the exact demand for extra matter, and will endeavor to insert such additional material in future editions.

A most important point to which attention is called is that all the illustrations in this volume are for the purpose of illustrating types of machines of which costs and performances are given. No quotation or price mentioned in these pages is to be taken as referring exclusively to any one machine illustrated or to the production of any one manufacturer. The prices are frequently averages of several quotations, while the illustration that goes with this price is that of a standard piece of equipment.

AIR COMPRESSORS

These machines are for the purpose of putting power into proper form for convenient and economical transmission. Many of the operations that formerly were done only by hand are now being accomplished by machinery and machine tools driven by compressed air or its substitute, compressed steam. Under many circumstances a drill can operate by steam as well as by air, while for the hand tools, such as riveters, stone cutters, etc., the use of steam is not convenient because of its high temperature and sometimes because of the dense white cloud of condensing steam which is opaque and wet. In general, air is never at a disadvantage as compared with steam in convenience of working; and where they are equally convenient the ruling economic feature is the distance to which the power must be transmitted. A boiler is less expensive than a boiler and compressor of the same power; hence for short distances the steam power is more economical, other conditions being equal. As the distance of transmission increases, the relative economy of the steam transmission decreases, on account of heat losses, and there is, therefore, a point at which the extra economy of the air transmission equals the extra cost of the compressor. For greater distances than this the air transmission is economic; below it direct steam is the less costly. The actual position of this critical point for each set of conditions depends on the conditions themselves and can be worked out when they are all determined. It should be remembered, when considering such a problem, that it is quite possible to carry steam for half a mile in well lagged pipe with inconsiderable heat losses.

The chief peculiarity of air compression for these purposes is that, as the air becomes compressed, its temperature rises. It may then be cooled at the place of compression by artificial means, or it may be admitted to the transmission pipes without first being cooled. In the latter case it becomes cooled more or less in transit, necessarily losing some of its pressure by the act of cooling, with a consequent loss of efficiency. For large installations, therefore, it is customary to do the cooling in the engine by a water jacket, or water jets.

A cubic foot of "free" air, at normal atmospheric pressure of 14.7 lbs. per square inch and initial temperature of 60° F., will have a temperature of about 225° F. and pressure of 2.64 atmospheres when compressed to one-half its original volume if there be no escape of the heat which is necessarily generated by the increase of pressure. This is "adiabatic" compression, or compression without loss of heat. If by a cooling arrangement the generated heat could all be removed as fast as generated, so that the temperature should remain constant, then the final pressure would be two atmospheres for the above example, and the compression would be "isothermal." In actual practice some heat is lost through the cylinders, so that neither the adiabatic nor isothermal curves represents accurately the facts.

If V represents final volume,
V′ represents initial volume,
P represents final pressure,
P′ represents initial pressure.

Then in general,

$$(1)\quad \frac{P}{P'} = \left(\frac{V'}{V}\right)^n$$

(2) For isothermal compression, $n=1$

(3) For adiabatic compression, $n=1.4$

For commercial machinery the exponent will be somewhere between these figures, depending upon the efficiency of the machine

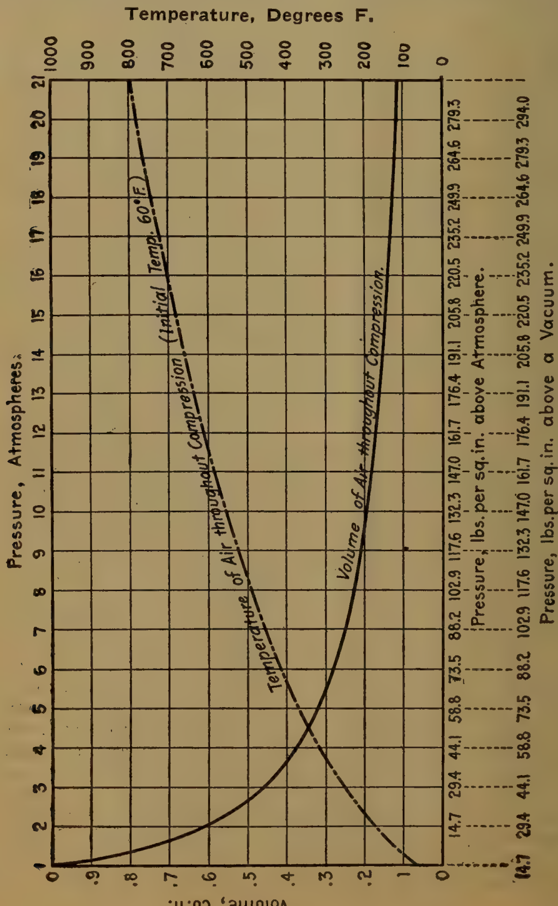


Fig. 1.

and the amount of cooling that is introduced into it. These three simple formulas combine the theoretical facts. The diagram on page 8, Fig. 1, giving in graphic form the adiabatic curves for temperature, pressure and volume will enable the approximate temperature to be obtained without tedious calculation.

There follows also a diagram, Fig. 2, from "Rock Drilling," by Dana and Saunders, from which may be obtained the cubic feet of free air required to run any number of drills at sea level and at various elevations.

Compressors may be divided into two general classes. The first classification divides them into the straight-line com-

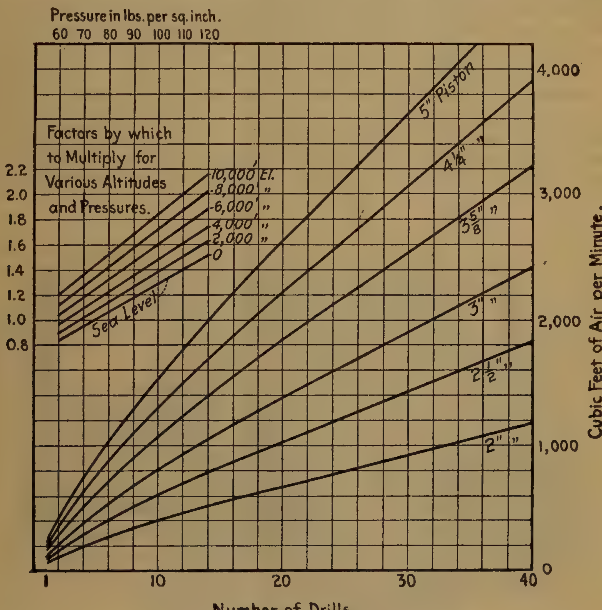


Fig. 2. Diagram Showing Cubic Feet of Free Air to Run from One to Forty Rock Drills at 75 lbs. per sq. in. Pressure.

pressor in which the steam and air cylinders are arranged in a straight line and the power is applied through a single long piston rod connecting all pistons; and into the duplex compressor which consists of two compressors set side by side, each made up of a steam and an air cylinder connected to a crank shaft carrying a single balance wheel. The cranks of the two sections are set at a 90° angle to each other with the object of producing no dead center and to enable the machine to operate at very low speeds.

The straight line machine is usually of lower cost, requires lighter foundation, occupies less room than the duplex, is more reliable in the hands of an average engineer and is a machine for every day service in moderate capacity. The duplex has more uniform operation, higher efficiency and greater steam economy. Another advantage is that in case of accident one side of the machine may remain uninjured and can be run in an emergency.

The second general classification divides them into steam driven and power driven compressors. In the former the steam cylinder is an integral part of the machine. In the latter the compressor is operated by power outside of the machine and may be driven by belts, ropes, chains, gears, or a direct shaft connection. Of these the belt driven is the most common and the direct shaft is used only with electric motors or water wheels. Compressors may be classed also as vertical and horizontal. The vertical type is advantageous where space is limited, as the machine is small, and is commonly restricted to the power driven class. The horizontal type is generally considered the better. Another classification is that of the single stage or compound stage. This has to do with the degree of compression to which the air must be subjected.

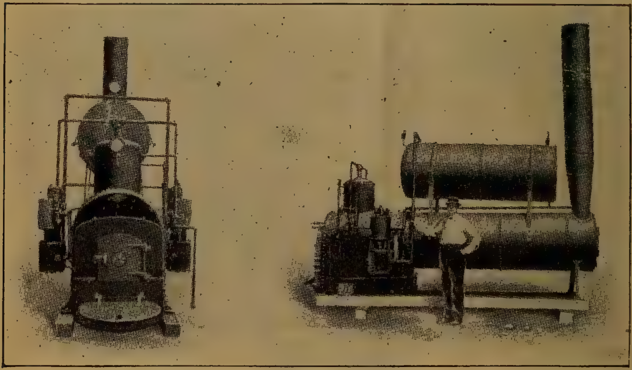


Fig. 3. Standard 9½-inch Compressors on Portable Boiler.

Locomotive Compressor. The simplest type of air compressor is the standard locomotive pump used for air brakes. This machine is of the straight line type and was originally designed for locomotive air brake use, but has since been applied to over one hundred different kinds of service, such as small pneumatic tool operation, cleaning metal surfaces, sand-blast outfits, in sewage ejectors, for pumping and conveying liquids.

Westinghouse Standard steam-driven air compressors are illustrated in Fig. 3 and the Cross-Compound by Fig. 4.

TABLE 1

	8-in.	9½-in	11-in.	Cross compound 10½ in
Diameter of steam cylinder	8″	9½″	11″	H. P. 8½″ L. P. 14½″
Diameter of air cylinder	8″	9½″	11″	H. P. 9″ L. P. 13½
Stroke	10″	10″	12″	12″
Steam admission pipe	1″	1″	1″	1″
Steam exhaust pipe	1¼″	1¼″	1½″	1½″
Air admission pipe	1½″	1½″	1½″	2″
Air delivery pipe..	1¼″	1¼″	1¼″	1½″
Rated speed, single strokes per min.	120	120	100	100
Displacement at rated speed.....	35 cu. ft.	49 cu. ft.	66 cu. ft.	115 cu. ft
Average actual displacement ..	20 cu. ft.	28 cu. ft	45 cu. ft.	50 cu. ft.
Overall dimensions	42x18x14″	42x18x15″	51x22x16″	52x37x18″
Net weight.......	450 lbs.	525 lbs.	850 lbs.	1,500 lbs.
Weight, boxed....	550 lbs.	625 lbs.	975 lbs.	1,750 lbs.
Price, f. o. b. factory	$90	$100	$150	$325

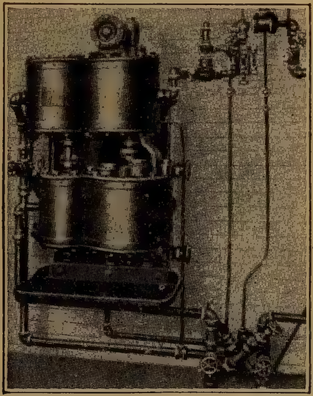


Fig. 4. One of Two Cross Compound Compressors Installed at the Plant of Heath & Milligan Manufacturing Co., Chicago, Ill.

This type of compressor requires no foundation (being bolted to a column or wall) nor accurate alignment of parts. The usual method of installing a water jacketed compressor of this type is

shown in Fig. 5. If the conditions do not require a water jacket the water pipe connections and valve, and radiating discharge pipe may be omitted. The approximate prices of the chief ele-

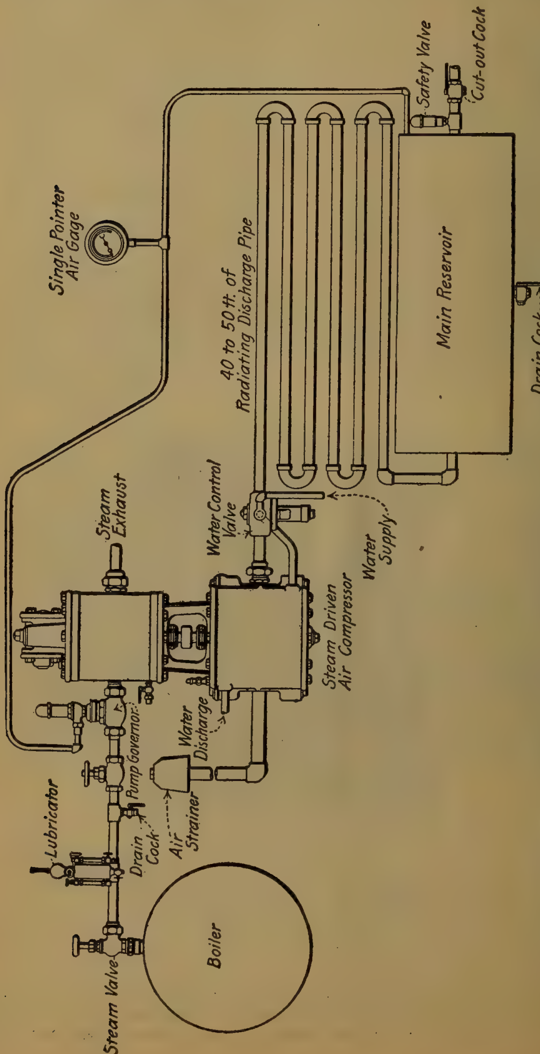


Fig. 5. Diagram of Installation of Steam Driven Air Compressor Plant.

ments are: Lubricator, $6.50; Governor, $14.00; Air gauge, $2.50; Main reservoir, $24.50; Drain cock, $1.00.

Standard electric railway compressors without water-jacket for use in connection with direct current and wound for 600 volts, have also found a great variety of uses where the operation is not continuous for over 20 minutes or 50% of the time. Fig. 6.

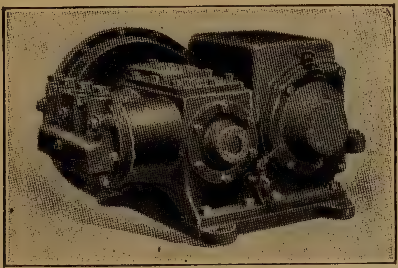


Fig. 6. Direct Current Motor Driven Air Compressor.

TABLE 2

Cyl. Diam. and stroke, inches	Displacement, cu. ft. per min. 100 lbs. air	Price	Shipping weight
5 x3	14½	$275	750 lbs.
5½x4½	25	325	1,100 lbs.
7 x5	38	425	1,400 lbs.
7¾x5	50	475	1,600 lbs.

Compressors of this type with direct current motors wound for other voltages, and with single, 2 phase, and 3 phase alternating current motors of various voltages and cycles are manufactured, but the prices vary too greatly to be tabulated.

Cost of Installation. In Gillette's "Rock Excavation" the cost of installing a compressor plant is given as follows:

Rand, Class C.

24x20-in. compressor, original cost, $4,000.00.
150 H. P. locomotive boiler which cost $1,000.00 (2nd hand).

Plant could furnish 1,300 cu. ft. free air per minute at 80 pounds pressure, or enough to run 10 or 12 drills.

Cost of installing boiler:

22 days, laborers, at $1.50	$ 33.00
23 days, engineers, at $3.00	69.00
13 days, mechanics, at $4.00	52.00
13 days, mechanics, at $2.00	26.00
1 day, bricklayer, at $4.00	4.00
Total	$184.00

Cost of installing compressor:

120 days, laborers, at $1.50	$180.00
4 days, engineers, at $3.00	12.00
22 days, mechanics, at $4.00	88.00
80 days, mechanics' help, at $2.00	160.00
50 days, carpenters, at $3.00	150.00
3 days, bricklayers, at $4.00	12.00
6 days, teams, at $4.00	24.00
8 days, foreman, at $3.00	24.00
Total	$650.00

Cost of materials:

15 M B. M. lumber for housing compressor, at $25	$375.00
1,400 sq. ft. tar paper (1 layer)	21.00
32 cu. yds. concrete, at $4.00	128.00
5 M brick, at $7.00	35.00
6 bbls. cement, at $2.00	12.00
Sand	1.00
Total	$572.00

Cost of large compressor plant. The following is the estimated cost of a compressed air plant in a western mine designed to furnish air for 20 drills of 3¼-in. size.

4 high pressure boilers (66 in. x 16 ft.)	$ 6,000.00
Housing and installing boilers	2,000.00
Duplex compound air compressor	16,000.00
Housing and installing compressor	2,000.00
Pipe, 1,000 ft. 6-in. and 1,500 ft. 1-in	1,200.00
Machine shop and tools	800.00
Total	$28,000.00

Estimating Costs. Mr. Gillette says it is usually safe to estimate on a basis of $1,000 per drill for the cost of a large and efficient compressor plant, and temporary housing and pipe line,

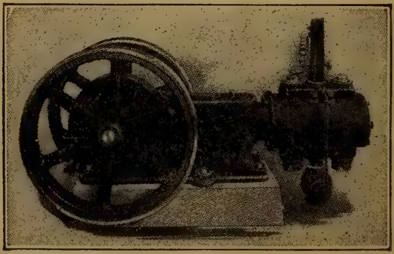


Fig. 7. Power Driven Single Stage Straight Line Air Compressor.

to which must be added the cost of the drill itself. If a more permanent building is provided, the corresponding cost of the compressor plant may be $1,500 per drill.

The prices of air compressors vary with the type, size, equipment and other conditions under which they are to be used.

Prices are herein given per cubic foot of displaced air for the commonly used sizes of compressors. Only a few of each type are tabulated as it is impossible to include all that are manufactured.

TABLE 3

POWER DRIVEN, STRAIGHT LINE, SINGLE STAGE, HORIZONTAL AIR COMPRESSORS

Size of air Cylinder		Displacement in Cu. Feet Free Air per Minute	Air Pressure (Lbs.)		Brake H. P. at Belt Pulley.		Dimen. Over All (Ft.)	Weight (Lbs.)
Diam. (Ins.)	Stroke (Ins.)		Min.	Max.	Min.	Max.		
6	6	40	45	100	5.5	8.5	5x2	1,420
8	8	100	50	100	12.5	19	6x2.5	2,500
10	6	115	15	20	8	10	5x2	1,750
10	10	180	55	100	25	36	7.5x3	4.000
12	8	205	20	30	16	22	6x2.5	3,100
12	12	310	60	100	46	62	11.5x4	7.500
14	10	335	25	35	30	38	10.5x3	5,000

The prices of compressors of this type range from $4.75 per cu. ft. of displaced air in the 6 x 6 size to $2.25 per cu. ft. in the 14 x 10 size.

TABLE 4

STEAM DRIVEN, STRAIGHT LINE, SINGLE STAGE, HORIZONTAL AIR COMPRESSORS

Steam Pressure 80-100 Lbs.

Size of Cylinders			Displacement in Cu. Feet Free Air per Minute	Air Pressure (Lbs.)		I.H.P. in Steam Cyl.		Dimensions			Weight (Lbs.)
Steam Cyl. Diam. (Ins.)	Air Diam. (Ins.)	Cylinder Stroke (Ins.)		Min.	Max.	Min.	Max.	Length (Ft.)	Width (Ft.)	Height (Ft.)	
6	6	6	40	45	100	5.5	8.5	7	2	5	2,000
6	10	6	115	15	20	8	10	7.5	2	5	2,500
8	10	8	145	30	50	14	20	9	2.5	5	3,700
10	10	10	180	55	100	25	36	10.5	3.5	5	6,100
10	12	10	260	35	55	28	38	11	3.5	5	6,500
12	12	12	310	60	100	46	62	15	4	6	9,100

The prices of compressors of the above type range from $8.30 per cu. ft. of displaced air for the 6 x 6 x 6 size to $3.10 per cu. ft. for the 12 x 12 x 12 size.

The larger sizes of steam driven, straight line, single stage compressors are as follows:

Steam Pressure 80-120 Lbs.

Size of Cylinders			Displacement in Cu. Feet Free Air per Minute	Air Pressure (Lbs.)		I.H.P. in Steam Cyl.		Dimensions			
Diam., Steam (Ins.)	Diam., Air (Ins.)	Stroke (Ins.)		Min.	Max.	Min.	Max.	Length (Ft.)	Width (Ft.)	Height (Ft.)	Weight (Lbs.)
18	18	18	630	40	80	75	115	15	4.5	4.5	17,500
18	20	24	805	40	90	90	150	19	5.5	5.5	24.500
20	22	24	975	40	85	110	175	19	5.5	5.5	25,500
20	24	24	1,150	25	50	95	150	19	5.5	5.5	26,500
22	22	24	975	50	100	124	188	19	5.5	5.5	27,000
24	24	24	1,150	40	80	125	200	19	5.5	5.5	27,500

The prices of the above type range from $3.20 per cu. ft. of displaced air in the 18 x 18 x 18 size to $2.50 per cu. ft. in the 24 x 24 x 24 size.

TABLE 5

STEAM DRIVEN, TANDEM, TWO-STAGE, HORIZONTAL COMPRESSORS

Steam Pressure 80-150 Lbs.

Size of Cylinders				Displacement in Cu. Feet Free Air per Minute	I. H. P. in Steam Cylinders, Sea Level, Pressure		Dimensions			
Diam., Steam (Ins.)	L. P. Air (Ins.)	H. P. Air (Ins.)	Stroke (Ins.)		90 Lbs.	110 Lbs.	Length (Ft.)	Width (Ft.)	Height (Ft.)	Weight (Lbs.)
14	16	10	14	690	120	130	18	4	6	19,500
18	20	13	18	1,115	185	205	21	4.5	7	28,000
22	24	15	24	1,645	270	300	26	5.5	8	43,000
24	27	16	27	2,180	355	395	29	6	8.5	52,000

The prices of the above type range from $2.90 for the 14 x 16 x 10 x 14 to $2.00 for the 24 x 27 x 16 x 27 per cu. ft. of displaced air. This type is largely used as a compressor of intermediate economy between the straight line and cross compound types.

TABLE 6

POWER DRIVEN, DUPLEX, CROSS-COMPOUND, HORIZONTAL COMPRESSORS

Size (Ins.)	Displacement, Cu. Ft. Free Air Per Minute	Price per Cu. Ft. Air Displaced	Weight (Lbs.)
10x 6x10	205	$4.30	7,300
14x 9x12	445	2.60	12,500
19x12x16	890	2.00	25.000
25x15x20	1,700	2.00	60,000

Further sizes of duplex single stage air compressors are not given as they are used only under special conditions where low

pressure air is required, such as caisson sinking, air lifts, etc., where each installation requires special cylinder sizes.

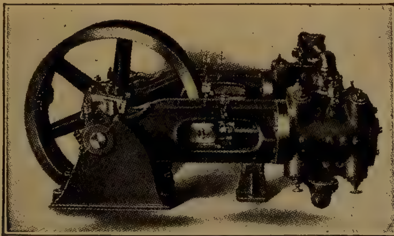


Fig. 8. Duplex Belt Driven Compressor.

TABLE 7

STEAM DRIVEN, DUPLEX, TWO-STAGE, HORIZONTAL COMPRESSORS

Steam Pressure 80-150 Lbs.

Size of Cylinders Diameters: Steam (Ins.)	L.P. Air (Ins.)	H.P. Air (Ins.)	Stroke (Ins.)	Displacement in Cu. Feet Free Air per Minute	I.H.P.: 80 Lbs. Air Press.	I.H.P.: 100 Lbs. Steam Press.	Dimensions (Ft.)	Weight (Lbs.)
7	10	6	10	205	32	35	9x5	8,900
9	14	9	12	445	70	80	10.5x6	13,000
12	19	12	16	890	140	160	13.5x9	25,500
16	25	15	20	1,700	270	300	17x11.5	55,000
18	28	17	24	2,380	375	420	19x12.5	68,000

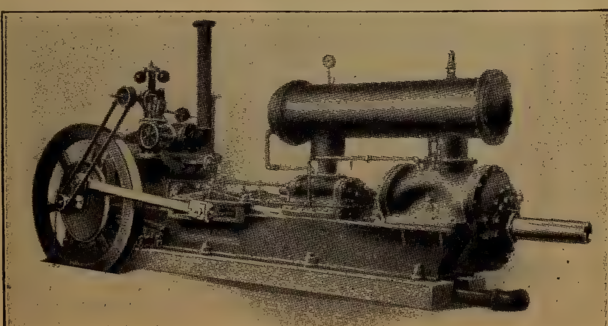


Fig. 9. Ingersoll-Rand Straight Line Steam Driven Two-Stage Air Compressor.

The prices of compressors of the above type with simple steam cylinders vary from $5.50 per cu. ft. of displaced air for the 7x10x6x10 size to $3.00 for the larger sizes. These compressors are usually sold with cross compound steam cylinders, which cost approximately 35 cents per cu. ft. extra.

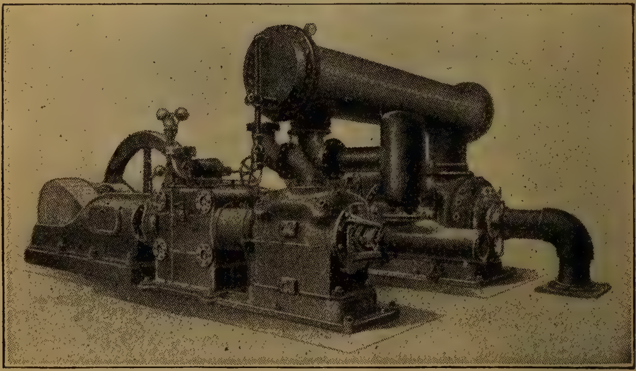


Fig. 10. Ingersoll-Rand Duplex Corliss Steam Driven Air Compressor.

TABLE 8

CORLISS ENGINE DRIVEN COMPRESSORS, SIMPLE STEAM, TWO-STAGE, AIR CYLINDERS

Steam Pressure 90-120 Lbs.

Size of Cylinders Diameters: Dup. Steam (Ins.)	L.P. Air (Ins.)	H.P. Air (Ins.)	Stroke (Ins.)	Displacement in Cu. Feet Free Air per Minute	I.H.P. in Steam Cylinder at Pressures: 90 Lbs.	110 Lbs.	124 Lbs.	Dimensions Ft.: Length	Width	Height	Weight (Lbs.)
16	27	16	24	2,000	305	320	342	31	14	10	75,000
18	30	18	27	2,590	390	410	440	34	14	10	92,500
20	33	20	30	3,340	505	530	560	37	15	11	125,000
22	37	22	36	4,200	625	665	705	42	15	12	158,000

The prices of these machines with simple steam cylinders range from $3.75 to $2.90 per cu. ft. of air displaced. They are usually sold with cross compound steam cylinders, which adds about 35 cents per cu. ft. extra to the price.

The foregoing list of compressors gives a complete line of the commonly used compressors starting from the small capacities of the less efficient designs through the various stages of de-

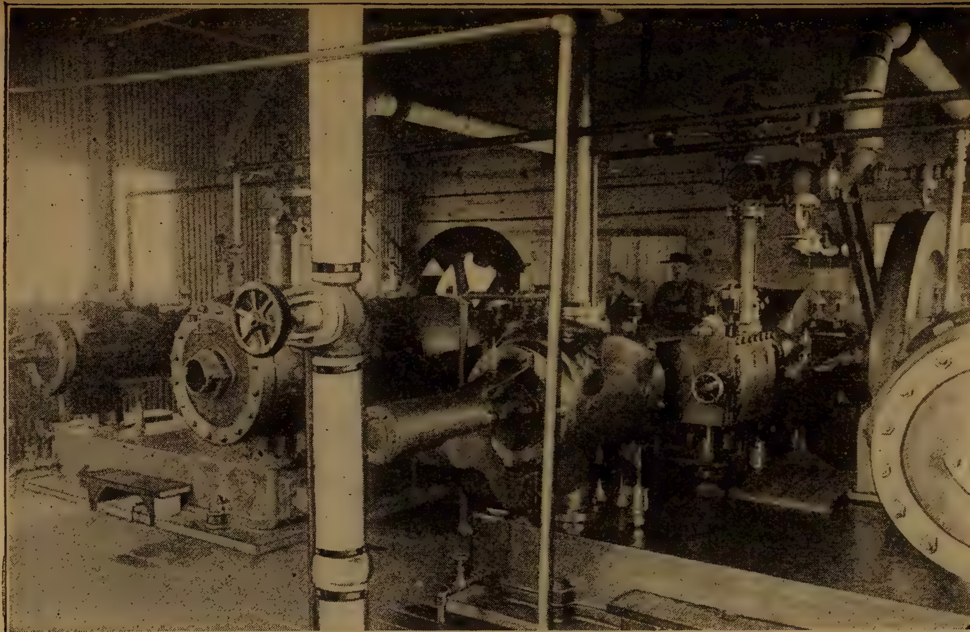


Fig. 11. Two of Class HH-3 Air Compressors, size 16 & 28 and 25¼ & 16¼x16, installed for the Water Department of the City of New York, and used to supply air for rock drills, pumps and general shaft and tunnel work, in driving the syphon under the Hudson River and at Storm-King-on-Hudson.

velopment to the larger and more efficient units of the highest type.

COST OF COMPRESSOR INSTALLATION

An air compressor, electric generating, and pumping outfit was installed for the Water Board of the City of New York at Cornwall Landing on the Hudson River, about 2,000 ft. south of the West Shore Railway Station. This plant was used to supply air for drills, pumps, and general shaft and tunnel work, in driving the siphon under the Hudson at Storm King Mountain.

Compressor equipment installed. Two (2) $\frac{16}{28} \times \frac{25\frac{1}{4}}{16\frac{1}{4}} \times 16$ Class "HH-3" cross compound steam driven air compressors, having a piston displacement each of 1392 cu. ft. designed to operate condensing; air pressure 100 to 110 lbs.; steam pressure 150 lbs.

One (1) 48" improved type of vertical aftercooler.

One (1) 54" dia. by 12' vertical air receiver.

Boiler equipment and pumps, etc. Three (3) 130 H. P. Sterling boilers.

Two (2) 6 x 4 x 6 outside packed boiler feed pumps built by the Buffalo Steam Pump Co.

Two (2) 6 x 5¾ x 6 piston type tank pumps built by the Buffalo Steam Pump Co.

One (1) 10 x 18 x 10 independent jet type condenser built by the Buffalo Steam Pump Co.

One (1) 400 H. P. enclosed Berriman type feed water heater built by the F. L. Patterson Co.

One (1) 20 K. W. Kerr steam turbine generating set built by the Atwood Reardick Co.

One (1) station panel complete with necessary switches, etc.

One (1) feed water tank.

2,500 ft. of 6-in. black wrought iron pipe.

2,500 ft. of 1½-in. 2 conductor cable.

The above equipment was installed on rented property on the Hudson River and immediately adjacent to the right of way of the West Shore Railroad. Cost including this equipment plus the cost of the railroad siding, actual building and foundations, piping in power house, boiler setting, together with all labor and other charges for putting this equipment into operation, laying the air pipe from the plant to the shaft, some 2,400 ft. distant, and electrical connections between shaft and power house, and adequate well to obtain boiler feed water and making proper connections to the Hudson River with strainer, etc. for condensing and circulating purposes, approximately $35,000.00, which includes the following costs: Compressors, aftercooler and receiver, approximately $13,500. Balance of equipment, consisting of boilers, pumps, generator set, water tank, pipe and electric conductor, etc., about $10,000. Railroad siding, building and foundations, piping in power house, boiler settings, well, erecting stacks, labor, superintendence, charges for placing plant in operation, rental, lease for railroad siding, and incidentals, $11,500.00.

Portable compressors. The Consolidated Gas Co. of New York uses lead wool for its gas mains and caulks it with a chipping hammer having a 3-in. stroke. This is operated by air supplied from a portable compressor outfit of light weight, having a self-contained water cooling system and a simple gasoline engine. The capacity is about 50-75 cubic feet of air, which is sufficient for 7 or 8 hammers. Table 9 (from an article by Colin C. Simpson, Jr., written for the American Gas Institute, 1910) shows the cost, air capacity, etc. of the various types of outfits investigated. Hand work, the method formerly employed, required

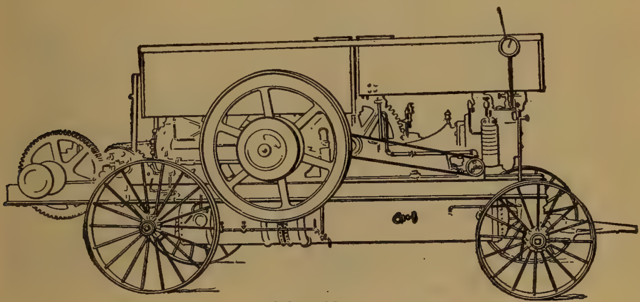


Fig. 12.

for each joint 2½ hours in yarning and 7 hours in caulking with lead wool; two men completed one joint in a 10-hour day. About 160 lb. of lead wool were used. With the compressed air outfit it is stated two men can yarn and caulk two joints in a 10-hour day. The men stand on either side of the main and the caulking iron is alternated between them. The pressure of the caulking iron is said to be uniform and to insure a perfect joint, using the same amount of lead wool pressed into a smaller space. The gas engine consumes about 1 gal. of gasoline per hour and the pressure maintained averages 600 lbs.

TABLE 9—SHOWING COST, AIR CAPACITY, ETC., OF DIFFERENT TYPES OF PORTABLE COMPRESSORS

Make of Outfit	Cu. Ft. Free Air per Min. Del'd (Mfr's Rating)	At Pressure of 100	Weight Complete	Type Compressor	Comp. Cooling System	Motive Power	Cooling System	Cost Complete
Abenaque	78	100	7,700	8 x 8 Ing.-Rand "NE-I" single stage water jacketed.	4 water cooling tanks with rotary circulating pump.	15 h.p. 1 cyl. Abenaque gasoline.	4 water cooling tanks	$1,425
Abenaque	64	100	7,800	6x8 Franklin single stage water jacketed.	4 water cooling tanks with rotary circulating pump.	15 h.p. 1 cyl. Abenaque gasoline.	4 water cooling tanks	$1,325
Chicago Pneumatic Tool Co.	70	90	over 7,000	6x8 Franklin single stage water jacketed.	Water circulation.	Gas and Air Cyl. cast in one piece, worked tandem with single piston rod.	Water circulation	$1,250
Fairbanks-Morse	70	80	8,900	8 x 8 Fairbanks-Morse.	Water circulation from tanks.	12 h.p. 1 cyl. gasoline	Water circulation from tanks	$1,120
Bury	94	90	9,000	9x8 Class B. B. Bury.	Water circulation from tanks.	20 h.p. gasoline 1 cyl.	Water circulation from tanks	$1,825
National Brake & Electric Co.	100	90	8,000	7½x9 3 cyl. Nat. Brake & Electric.	Water circulation with radiator.	4 cyl. gasoline marine type 27 h.p.	Water circulation with radiator	$1,900

Gloucester, Mass., has large areas covered with glacial boulders, which add greatly to the cost of any sort of excavation and here steam tripod drills, operated by portable boilers, were used to blast these boulders until March, 1910, when a single stage air compressor, driven by a 15 H. P. gasoline engine, the whole mounted on a steel truck, was purchased by the city. An air cylinder of 8 x 10 inches gave 96 cubic feet of free air per minute

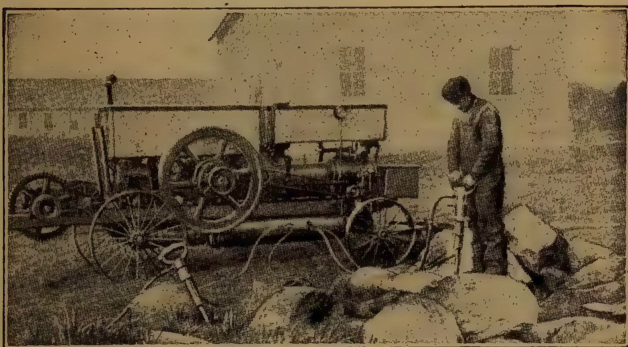


Fig. 13. Sullivan "WK-3" Air Compressor Outfit and Sullivan "DB-15" Hammer Drills.

at 165 revolutions with 80 to 100 lbs. air pressure. A hoisting attachment was mounted on the rear of the truck for pulling rock fragments from trenches, etc. Besides this, the machine was provided with a gasoline tank, cooling tanks, and an air receiver. The outfit weighed 8,000 lbs. Hammer drills were used, and holes 5 ft. deep were frequently drilled in 30 minutes. The price of a similar machine complete is $1,350.00.

An outfit like this with 3 hammer drills has been used at Yonkers, on similar work. Each drill averaged 50 ft. per day and the cost of operation was as follows:

3 drill operators at $3.50 per day	$10.50
Compressor attendant	3.50
Gasoline, 15 gallons at 20c	3.00
Interest, renewals, wear and tear	6.00
Total cost	$23.00

This gives a cost of 14½ cts. per ft. of hole. The work was formerly done by hand at 30 cts. per ft.; each man received $1.50 per day and averaged 5 ft. of hole.

Air Gage at Drill.	60 lbs.	65 lbs.	70 lbs.	76 lbs.	82 lbs.	88 lbs.	95 lbs.
12,000 ft. Alt.	G	H	I	J	K	L	M
10,000 " "	F	G	H	I	J	K	L
8,000 " "	E	F	G	H	I	J	K
6,000 " "	D	E	F	G	H	I	J
4,000 " "	C	D	E	F	G	H	I
2,000 " "	B	C	D	E	F	G	H
Sea Level	A	B	C	D	E	F	G

Relative Capacity of Rock Drills:

2"	.55	$3\frac{1}{4}$"	1.07
$2\frac{1}{2}$"	.60	$3\frac{1}{2}$"	1.20
$2\frac{3}{4}$"	.90	$4\frac{1}{4}$"	1.33
3"	1.00	5"	1.55

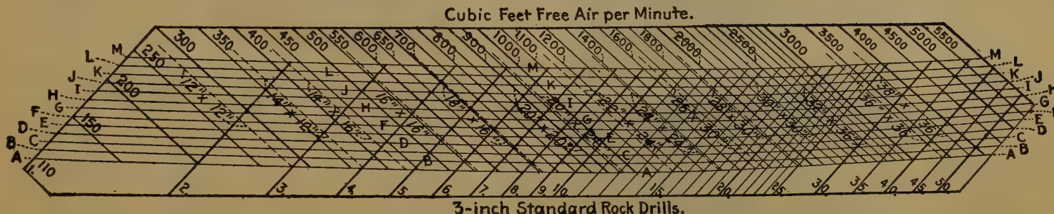


Fig. 14. Diagram Showing Air Required for Rock Drills.
(Printed by permission of the Norwalk Iron Works, South Norwalk, Conn.)

Directions:

1. If the drills are not of the 3-in. size, find out the number of 3-in. drills which equals the drills proposed for use. The diagram of "Relative Capacity of Rock Drills" is for this purpose.
2. Observe the height above sea level.
3. Determine the air pressure that you would carry on the drill.
4. The size of the compressor in free air capacity at the given altitude will be found in the diagram.

In the table of altitudes opposite each height and under the line of pressure is found a letter, as for 8,000 ft. under 76 lbs. we find H. On the diagram we find horizontal lines A, B, H, M, etc. We also find diagonal lines leaning to the right marked with numbers of 3-in. drills; also diagonal lines leaning to the left marked "cu. ft. free air per minute." The meeting point of the rock drill line with the lettered altitude line will indicate the free air capacity needed in compressors. For example, 10 drills, at 8,000 ft. and 76 lbs. We find the 10 drill line meets the line marked H just below the cu. ft. capacity line marked 1,300; thus indicating the capacity needed in the compressor. In the same way 88 lbs. at 6,000 ft. altitude take the letter I, and for six drills the drill line meets I just below the air capacity line 900, or 20 x 20 compressor.

As it is a very common practice to use air in drills and light machines at full stroke, I append a table of efficiency of compressors when the air is so used at 60 lbs. per sq. in. gauge pressure, and at various heights above sea level.

TABLE 10

Height in Feet Above Sea Level	Barometer, Inches	Efficiency of Compressor, Per Cent
0	30	100.0
500	29.42	98.4
1,000	28.85	96.9
1,500	28.34	95.5
2,000	27.78	94.0
3,000	26.74	91.1
4,000	25.70	88.1
5,000	24.73	85.9
6,000	23.83	82.8
7,000	22.93	80.2
8,000	22.04	77.5
9,000	21.22	75.1
10,000	20.43	72.7
12,000	18.92	68.0

TABLE 11—SIZES OF COMPRESSORS

Diam. Air Cylinder	Length of Stroke	Diam. of Compressing Cylinder	Diam. of Steam Cylinder	Revolutions per Minute	At Sea Level: Displacement Capacity, Cubic Feet	At Sea Level: Horsepower	At 2,000 Ft.: Capacity	At 2,000 Ft.: Horsepower	At 6,000 Ft.: Capacity	At 6,000 Ft.: Horsepower	At 10,000 Ft.: Capacity	At 10,000 Ft.: Horsepower
12	12	6¾	10	180	282	35	264	34	234	32	207	30
14	12	9½	12	180	390	50	368	48	325	46	280	44
16	16	9½	14	150	558	80	524	78	462	74	405	70
18	16	10½	16	150	707	100	664	97	587	91	516	86
20	20	13½	18	125	909	130	854	125	752	115	660	109
22	24	13½	20	110	1,160	170	1,090	165	960	158	843	150
24	24	14½	22	110	1,380	200	1,297	194	1,145	184	1,007	172
26	30	17½	24	90	1,659	240	1,560	232	1,373	221	1,200	206
30	30	19	28	90	2,209	330	2,076	310	1,829	295	1,606	275
32	36	20	30	80	2,680	390	2,525	378	2,229	361	1,960	335
38	36	22	36	80	3,780	575	3,550	531	3,134	507	2,756	475

In the above table the capacity at a height is stated less than at sea level. The displacement capacity is really the same at all altitudes, but at a height this capacity is equivalent in its results to a smaller compressor at sea level, and for convenient comparison this equivalent capacity is given. The following tables are compiled for use under fair conditions in ordinary hard rock. It is well to provide a capacity 25% in excess of the anticipated requirements.

TABLE 12—CUBIC FEET OF FREE AIR REQUIRED TO RUN ONE DRILL OF THE SIZE AND AT THE PRESSURE STATED BELOW

Gauge Press. Lbs.	A35	A32	B	C	D	D	D	E	F	F	G	H	H9
	Size and Cylinder Diameter of Drill												
	2"	2¼"	2½"	2¾"	3"	3⅛"	$3\frac{3}{16}$"	3¼"	3½"	3⅝"	4¾"	5"	5½"
60	50	60	68	82	90	95	97	100	108	113	130	150	164
70	56	68	77	93	102	108	110	113	124	129	147	170	181
80	63	76	86	104	114	120	123	127	131	143	164	190	207
90	70	84	95	115	126	133	136	141	152	159	182	210	230
100	77	92	104	126	138	146	149	154	166	174	199	240	252

TABLE 13—MULTIPLIERS TO DETERMINE CAPACITY OF COMPRESSOR REQUIRED TO OPERATE FROM 1 TO 70 ROCK DRILLS AT ALTITUDES COMPARED WITH SEA LEVEL

Altitude Above Sea Level (Ft.)	NUMBER OF DRILLS 1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	60	70
	Multipliers																		
0	1.	1.8	2.7	3.4	4.1	4.8	5.4	6.0	6.5	7.1	8.1	9.5	11.7	13.7	15.8	21.4	25.5	29.4	33.2
1,000	1.03	1.85	2.78	3.5	4.22	4.94	5.56	6.18	6.69	7.3	8.34	9.78	12.05	14.1	16.3	22.0	26.26	30.3	34.2
2,000	1.07	1.92	2.89	3.64	4.39	5.14	5.78	6.42	6.95	7.60	8.67	10.17	12.52	14.66	16.9	22.9	27.28	31.46	35.52
3,000	1.10	1.98	2.97	3.74	4.51	5.28	5.94	6.6	7.15	7.81	8.91	10.45	12.87	15.07	17.38	23.54	28.05	32.34	36.52
4,000	1.14	2.05	3.08	3.88	4.67	5.47	6.15	6.84	7.41	8.09	9.23	10.83	13.34	15.62	18.01	24.4	29.07	33.52	37.8
5,000	1.17	2.10	3.16	3.98	4.8	5.62	6.32	7.02	7.61	8.31	9.48	11.12	13.69	16.03	18.49	25.04	29.84	34.4	38.84
6,000	1.20	2.16	3.24	4.08	4.9	5.76	6.48	7.2	7.8	8.52	9.72	11.4	14.04	16.44	18.96	25.68	30.6	35.4	39.84
7,000	1.23	2.21	3.32	4.18	5.04	5.9	6.64	7.38	7.99	8.73	9.96	11.68	14.39	16.85	19.43	26.32	31.36	36.16	40.84
8,000	1.26	2.27	3.40	4.28	5.17	6.05	6.8	7.56	8.19	8.95	10.21	11.97	14.74	17.26	19.9	26.96	32.13	37.04	41.83
9,000	1.29	2.32	3.48	4.39	5.29	6.19	6.96	7.74	8.38	9.16	10.45	12.26	15.09	17.67	20.38	27.6	32.9	37.92	42.83
10,000	1.32	2.38	3.56	4.49	5.41	6.34	7.13	7.92	8.58	9.37	10.69	12.54	15.44	18.08	20.86	28.25	33.66	38.8	43.82
12,000	1.37	2.47	3.7	4.66	5.62	6.57	7.4	8.22	8.9	9.73	11.1	13.02	16.03	18.77	21.64	29.32	34.94	40.28	45.48
15,000	1.43	2.57	3.86	4.86	5.86	6.86	7.72	8.58	9.3	10.15	11.58	13.58	16.73	19.59	22.59	30.6	36.46	42.04	47.47

Example.—Required the amount of free air necessary to operate thirty 5-inch "H" drills at 9,000 feet altitude, using to operate these drills air at a gauge pressure of 80 pounds per square inch.

From Table 12 we find, when operating the drills at 80 pounds gauge pressure at sea level, that one 5-inch "H" drill requires 190 cubic feet of free air per minute.

From Table 13 we also find that the factor for 30 drills at 9,000 feet altitude is 20.38; multiplying 190 cubic feet by 20.38 gives 3,872 cubic feet free air per minute, which is the displacement of a compressor for the above outfit under average conditions, to which must be added pipe line losses, such as friction and leakage.

TABLE 14—COMPRESSED AIR TABLE FOR PUMPING PLANTS

For the convenience of engineers and others figuring on pumping plants to be operated by compressed air, the following table by which the pressure and volume of air required for any size pump can be readily ascertained is given. Reasonable allowances have been made for loss due to clearances in pump and friction in pipe.

PERPENDICULAR HEIGHT, IN FEET, TO WHICH THE WATER IS TO BE PUMPED

Ratio of Diameters.	25	50	75	100	125	150	175	200	225	250	300	350	400	450	500	
1 to 1	13.75	27.5	41.25	55.0	68.25	82.5	96.25	110.0	.....	.....	.....	.....	.....	.....	.....	Air pre'ure at pump
	0.21	0.45	0.60	0.75	0.89	1.04	1.20	1.34	.....	.....	.....	.....	.....	.....	.....	Cubic ft. of free air per gal. of water.
1½ to 1	.....	12.22	18.33	24.44	30.33	36.66	42.76	48.88	55.0	61.11	73.32	85.4	97.66	.....	.....	Air pre'ure at pump
	.....	0.65	0.80	0.95	1.09	1.24	1.39	1.53	1.68	1.83	2.12	2.41	2.70	.....	.....	Cubic ft. of free air per gal. of water.
1¾ to 1	.....	.....	13.75	19.8	22.8	27.5	32.1	36.66	41.25	45.83	55.0	64.16	73.33	82.5	.....	Air pre'ure at pump
	.....	.....	0.94	1.14	1.24	1.30	1.54	1.69	1.84	1.99	2.39	2.59	2.88	3.19	.....	Cubic ft. of free air per gal. of water.
2 to 1	.....	.....	.....	13.75	17.19	20.63	24.06	27.5	30.94	34.38	41.25	48.13	55.0	61.88	68.75	Air pre'ure at pump
	.....	.....	.....	1.23	1.37	1.52	1.66	1.81	1.96	2.11	2.40	2.69	2.98	3.28	3.57	Cubic ft. of free air per gal. of water.
2¼ to 1	.....	.....	.....	.....	13.75	16.5	19.25	22.0	24.75	27.5	33.0	38.5	44.0	49.5	55.0	Air pre'ure at pump
	.....	.....	.....	.....	1.533	1.68	1.83	1.97	2.12	2.26	2.56	2.85	3.15	3.44	3.73	Cubic ft. of free air per gal. of water.
2½ to 1	.....	.....	.....	.....	.....	13.2	15.4	17.6	19.8	22.0	26.4	30.8	35.2	39.6	44.0	Air pre'ure at pump
	.....	.....	.....	.....	.....	1.79	1.98	2.06	2.104	2.34	2.62	2.88	3.18	3.36	3.23	Cubic ft. of free air per gal. of water.

To find the amount of air and pressure required to pump a given quantity of water a given height, find the ratio of diameters between water and air cylinders, and multiply the number of gallons of water by the figure found in the column for the required lift. The result is the number of cubic feet of free air. The pressure required on the pump will be found directly above in the same column. For example: The ratio between cylinders being 2 to 1, required to pump 100 gallons, height of lift 250 feet. We find under 250 at ratio 2 to 1, the figures 2.11; 2.11 x 100=211 cubic feet of free air. The pressure required is 34.38 pounds delivered at the pump piston.

ASBESTOS

Asbestos building felt and **sheathing** in less than ton lots costs 3½c per pound for the light material weighing from 6 to 30 pounds per 100 sq. ft., 4c per pound is charged for the heavy asbestos weighing from 45 to 56 pounds per 100 sq. ft.

Mill board is made in standard sheets, 40x40 ins., and 41x40 ins. It varies in thickness from 1-32 to ½ in. and in weight from 2 to 27 lbs. per sheet. The net price in 100-pound lots is 5c per pound.

Transite, asbestos wood, used for fireproofing, ventilators and smoke jackets, comes in standard sheets, 36x48 ins. and 42x96 ins. The prices f. o. b. factory are as follows:

Thickness.	Weight.	Price per sq. ft.
⅛ inch	1 lb.	$0.08
3/16 "	1½ "	.12
¼ "	2 "	.16
5/16 "	2½ "	.20
⅜ "	3 "	.28
7/16 "	3½ "	.28
½ "	4 "	.32
9/16 "	4½ "	.36
⅝ "	5 "	.40
¾ "	6 "	.44
⅞ "	7 "	.48
1 "	8 "	.52
1¼ "	10 "	.56
1½ "	12 "	.64
1¾ "	16 "	.72
2 "	16 "	.80

Asbestos cements are used for covering boilers, domes, fittings, etc., and all irregular surfaces, and may be used over asbestos air cell boiler blocks, when it makes an excellent covering. When mixed with water to a consistency of mortar and applied with a trowel, it forms a light porous coating which is the most efficient non-conductor. The cost of this cement is $33.00 per ton.

ASPHALT PLANTS

ASPHALT MIXING PLANTS

A semi-portable asphalt mixing plant (Fig. 15) designed to meet the requirements of paving contractors and municipal street repair work consists of a double drum dryer with cold material elevator. The dried materials are delivered into a hopper and thereby conveyed to the hot material elevator, from which they are discharged directly into the revolving screen which is located above the hot material bin. This bin is supported in a tower and from it the hot materials are delivered to a measuring box in which the materials may be either measured or weighed. The melting tanks (of one thousand gallons capacity each) are arranged in a battery of six and are pro-

Fig. 15. Iroquois Semi-Portable Asphalt Mixing Plant for Municipal Repair Plant or General Contractors' Use.

vided with suitable covers, and from them the asphalt is conveyed to the bucket by the dipping process. This bucket is arranged with trolley track and each batch of asphalt can be weighed. The mixer is provided with two sets of shafts which may be easily interchanged for mixing either binder or topping. The power plant consists of a locomotive type boiler with a 50 h. p. engine mounted thereon.

The engine and boiler are mounted on skids and there are no heavy foundations necessary, thereby making the plant easy to

remove. The plant has 1,000 square yards per day capacity; total weight, 63 tons; price, f. o. b. Buffalo, N. Y., $10,500.

An asphalt mixer was used in Lincoln Park, Chicago, during 1910 to construct an asphalt surfaced driveway. The road was 40 ft. wide x 4,631 ft. long, and had 2 inches of asphalt on an 8 in. base of crushed stone. The total amount of asphalt was 22,318 sq. yds. The material was mixed in an asphalt mixer in the following proportions:

	Lbs.
1 part torpedo sand	168
1 part bank sand	165
3 parts ½-in. stone	504
Asphalt	81
Total 7 cu. ft. or 1 box	921

The total costs were as follows:

Labor on stone, per sq. yd.	$0.498
Labor on asphalt, per sq. yd.	.352
Stone for base, per sq. yd.	.394
Asphalt material	.394
Total per square yard	$1.638
Labor cost of curb, per lin. ft.	.64
Material cost of curb, per lin. ft.	.21
Total cost of curb	$0.85

These costs include all repairs to the plant, but no depreciation. The cost of the plant was as follows:

Link Belt Co., asphalt mixer	$ 5,590
Gasoline tractor	1,200
6-ton roller	1,800
15-ton roller	1,500
Asphalt tanks and tools	1,000
Total value of plant	$11,090

ASPHALT REPAIR PLANTS

The municipal asphalt repair plant of Indianapolis, Ind., is described in *Engineering and Contracting*, Vol. XXXI, No. 4.

The plant has a capacity of 1,200 square yards of 2 in. asphalt per day, and cost $15,525. The total cost, including one 5-ton steam roller, four dump wagons, five wagons, office building, roller, stone dust and tool sheds, all tools necessary, and the preparation of the yard was $20,557.68.

From June 16 to December 31, 1908, 101,743 square yards of surface mixture were turned out at a total cost of about 64 cents per square yard. One day was lost on account of rain, four days waiting for material and seven hours for repairs to plant.

The cost of material used was, for California asphalt $23 per ton, for Trinidad asphalt $29 per ton, for limestone dust $3 per ton, for residuum oil (average) 5 cents per gallon, and for sand 90 cents per cubic yard.

The municipal asphalt repair plant of New Orleans, La., was erected on a lot 175 ft. x 260 ft., and covers about 1,500 square feet of ground.

The cost of plant was as follows:

Demolition of old garbage plant buildings	$ 475.00
Asphalt plant—Warren Bros. Asphalt Paving Co.'s contract, $16,862.50; city alterations and additions, $2,736.50	19,599.00
Yard fences and gates	859.00
Switch tracks	1,189.00
Yard pavements and drains	6,721.00
Tower tank and filter	1,330.00
Water pipes and outlets	1,015.00
Waterhouse and platform	1,471.00
Asphalt shed	289.00
Blacksmith shop and equipment	222.00
Stable, rolling pen and wagon shed	5,311.00
Stone crusher and storage bin	1,966.00
Yard material bins	332.00
Office and store room building	5,509.00
Landing bins and roads	1,432.00
Lighting	352.00
General cleaning of premises	298.00
Total	$48,370.00

In addition to 134 tools of various kinds included in the contract price, the plant is furnished with the following: 1 roller-mounted platform scales; 1 4-wheel hand truck; 12 wheelbarrows, 18 shovels; 10 axes; 6 picks; 8 crowbars; 8 sledge hammers; and a number of small tools. The shed tools consist of the following: 2 tool boxes; 18 street barriers; 1 8-ton steam roller; 1 3½-ton steam roller; 1 1,000-lb. hand roller; 1 fire wagon; 1 mixing kettle; 18 asphalt irons; 66 asphalt axes; 107 picks; 18 mattocks; 142 shovels; 24 wheelbarrows; 6 axes; 200 ft. of hose; 6 sledge hammers; 8 chisels; 10 iron bars; and other small tools. The testing laboratory is equipped with cement testing apparatus, oil testers, brick testers, etc.

In addition, 17 mules, 3 horses, 8 sets harness, halters, blankets, etc., for the stable, and 10 wagons, 8 carts, 2 farm wagons, 1 float dray and 1 buggy were purchased.

This equipment cost as follows:

Live stock, harness and stable equipment	$ 6,197.00
Rolling stock and equipment	3,180.00
Plant tools	837.00
Street tools	5,492.00
Office furniture	447.00
Laboratory equipment	1,490.00
Total	$17,643.00

Additional equipment was as follows:

1 7-ton steam road roller	$1,113.00
1 steel road grading machine	150.00
1 700-gallon capacity road sprinkler	396.00
Rolling stock	1,027.00
Railroad plows with extra points	39.00
Wheel scrapers	140.00
Harness	139.00
Live stock	1,700.00
Total	$4,704.00

From September 1, 1906, to August 31, 1907, supplies cost as follows:

	Av. Unit Cost	Total
Asphalt, 465.99 tons	18.50	$8,561
Fluxing oil, 125,527 lbs.	.0075	940
Naphtha, 6,753 gals.	.15	1,019
Lake shore sand, 2,580 cu. yds.	.99	2,566
River sand, 1,779 cu. yds.	1.64	2,920
Tchefuncta River sand, 250 cu. yds.	1.60	400
Mineral dust, 321 tons	5.50	1,764
River gravel, 564 cu. yds.	2.27	1,272
Cement, 1,936 bbls.	2.04	3,944
Coal, 389 tons	2.84	1,105
Clay gravel, 3,178 cu. yds.	1.50	4,786
New small granite blocks, 3,240	.07	227
Old small granite blocks, 4,600	.04	184
New building brick, 9,000		98
Old building brick, 8,500		25
Pine wood, 49¾ cords	5.68	283
Oak wood, 41½ cords	6.74	280
Lake shells, 3,618 cu. yds.	1.46	5,304
Brickbats, 696 cu. yds.	1.48	1,032
Cast iron, 32,924 lbs.		1,289
Drain pipes and Ys, 3,026 lin. ft.		979
Laboratory supplies		24
Office supplies, stamps, etc.		436
Engineers' supplies		606
Oats, 122,172 lbs.	.015	1,820
Bran, 6,600 lbs.	.01	66
Hay, 39¾ tons	24.72	983
Stable supplies		309
Blacksmith supplies		87
		$43,309

During the same period of time the plant turned out 88,947 cubic feet of wear surface which equals 49,415 square yards of 2-inch pavement.

The largest day's run was 205 boxes of wearing surface mixture. One box, or 9 cubic feet, will lay 5 square yards of 2-inch pavement.

AUTOMOBILES

These are of two main classes, those for transporting men, and those for materials and supplies.

Passenger Cars. For use of a superintendent, the passenger automobile, enabling him to go from place to place with speed and convenience, is practically indispensable. Their first cost is known to almost everyone who reads the papers, but the cost of operation, which is the important feature, seems to be a mystery to owners until a few months after they have had their cars in commission. The medium priced car, say from $1,200 to $1,800 for a five-passenger touring car equipped, is worth at the end of its first year a little less than two-thirds of its first cost if in proper repair, newly painted and usually with two new tires. After the first year the rate of depreciation is a little less, say, 25 per cent of the original cost when new. It is reasonably safe to figure about as follows for a standard American car:

Depreciation per year	25%–40%
Interest	6%
Repairs and painting	10%–20%
Storage (garage) (if in cities) (Less in country)	15%–30%
Gasoline and oil, 10,000 miles	5%–15%

These figures are intended to represent average conditions, and may easily be exceeded by careless handling or rough usage, and, on the other hand, may be too high for certain conditions. The very high priced cars will not depreciate as fast as 25 per cent, while the very low ones may depreciate faster than 40 per cent. If given less than average use the repair bill will be low, and the gasoline and oil costs will be reduced in proportion. If not used at all, but stored at a minimum rate of 5 per cent, the above costs will foot up to 36 per cent of the cost of the car new, while with very moderate usage 50 per cent would seem none too high. The proper unit for gasoline cost is that of the car mile, but here it has been assumed to be on the basis of gasoline at 15 cents per gallon and twelve car miles per gallon of gasoline. I have allowed ¼ cent per mile for oil, making 1.5 cents per mile in all, or $150 for 10,000 miles, which would be 10 per cent of the first cost of a $1,500 car. The other figures are properly in terms of percentage of first cost per year, and the fuel costs have been assumed as above to get them into the same units for comparison. The last item is relatively unimportant, and becomes insignificant if the car is not much used.

If the average $1,500 car is used 200 days in the year, averaging fifty miles per day, its daily cost on the above basis will be $6.45, which, allowing for chauffeur and overhead expenses, checks with the ordinary rental charges. The automobile manufacturing industry at present (1912) is growing faster than the

demand for cars, with a rapidly decreasing price for standard cars, at the same time that competition is keeping up the quality of the marketable cars. There will be, therefore, a smaller demand and lower prices for second-hand cars; hence the figures for depreciation will in the future tend to increase. The price of gasoline is not likely to be lowered, but is gradually advancing, and repair and storage rates tend to increase with the lapse of time. Consequently, the total percentage for annual maintenance cost, in terms of the selling price, is likely to grow from year to year the country over, the selling prices tending to steadily decline until they reach a standard cost of production plus standard overhead charges and reasonable profits. At the present writing, 1914, they are still at a considerable distance from this standard point.

Many figures of "sworn statements" as to repair costs have been published in the interests of the manufacturers of cars. These may be useful as advertising matter, but they are hardly a safe guide when financing a purchase.

Freight Cars, Trucks. The value of an automobile truck for handling materials and supplies depends on a good many factors that are often not familiar to a contractor, especially when he has no data except those furnished him (for nothing) by the willing salesman. The motor truck has certain marked characteristics that place it in a distinct class by itself. When comparing it with two-horse wagons these peculiarities must be considered to avoid an erroneous conclusion. The common unit of possible comparison is the ton of "live load" transported. The cost of loading and unloading may be assumed to be the same with motors as with horses. The essential factors are, therefore, as follows:

W=net live load in tons, average,
M=dead load of vehicle in tons,
S=speed loaded in feet per minute,
KS=speed empty in feet per minute,
D=distance of haul in feet, one way,
L=lost time in one average round trip, waiting to load and unload, breakdowns, etc., in minutes,
F=fixed charges per working day, such as I=interest and insurance,
D=depreciation,
S=storage,
O=operating expenses per working day, such as f=fuel, waste, oil, etc.
L=chauffeur and other labor,
R=repairs,
m=number of minutes in the working day,
R=transportation cost per ton.
n=number of round trips per working day of m minutes.

Then we have the following formulæ:

(1) $\frac{D}{S}$ =time in minutes for a loaded trip,

$\frac{D}{KS}$ =time in minutes for an empty trip,

(2) $L+\frac{D}{KS}$=actual non-productive time per round trip,

(3) $L+\frac{D}{KS}+D/S$=total average time for one round trip

$$=L+\frac{D}{S}\left(1+\frac{1}{K}\right)$$

(4) $\dfrac{m}{L+\frac{D}{S}\left(1+\frac{1}{K}\right)}$=total number of round trips per day. This in the majority of cases must be either an integral number or an integral plus ½, since the truck must usually tie up for the night at one end of the trip.

(5) $\dfrac{m\,W}{L+\frac{D}{S}\left(1+\frac{1}{K}\right)}$=Average load transported per day, in tons.

(6) $\dfrac{(O+F)\left[L+\frac{D}{S}\left(1+\frac{1}{K}\right)\right]}{m\,W}$=R=cost of transportation per ton for distance D

$\frac{W}{M}$ =weight of load divided by weight of vehicle, and

(7) $\frac{W}{M+W}$=live load divided by total load, giving the measure of carrying efficiency of the vehicle.

There are eight factors composing the quantity R, and these seven formulas give us all the essential relations for determining the economic policy to be pursued for any given conditions from which the values of the eight factors can be determined.

Several of these may be taken as standard, while two, namely, the practicable net load and the distance of haul, will vary with the nature of the work and the hourly conditions on the work.

To make proper comparisons between an automobile truck and other means of transportation, the cost curves for each method should be plotted and the costs thus readily be estimated.

Automobiles range in price from $500 for a 700-pound delivery wagon to $6,000 for a 7-ton truck. Prices as given are usually for the chassis alone and do not include the body, which latter may be had in a variety of forms at little above actual cost. Some types of body are very ingeniously designed and the removable body is of especial interest. This is made separate and of a size to suit the work it has to perform, and is mounted on rollers and can be removed from the chassis and rolled onto a hand truck or other support and while it is being loaded or unloaded the chassis is performing its work with another body of the same type. This is very valuable on short hauls, or where material which is difficult to handle is being carried, where the loading charge would be a large part of the total.

Mr. Charles L. Gow, in a paper read before the Boston Society of Civil Engineers, cites an instance where the 5½-mile road from the railroad to the work was in such bad condition and of such steep grades that 2-horse and sometimes 4-horse wagons were unable to make more than two trips per day, carrying 3,000 pounds. A steam traction engine failed of greater success on

account of the bad roads and because the steep grades going up hill caused the steam dome to be flooded and going down caused the crown sheet to be uncovered. A gasoline traction engine failed because of the presence of sandy patches in the road which destroyed the tractive force of the wheels. A 2-ton 38.5 horsepower automobile truck was introduced with great success, making six trips per day over a longer but better road. However, the use of the truck on the steep, icy roads became too dangerous and was stopped during the winter. Mr. Gow says: "It is highly probable that had two of these trucks been purchased at the beginning of the work great saving would have been effected in the cost of handling materials."

Forbes & Wallace put a gasoline machine in service May 1, 1909, to deliver bundles from their department store. The result of eight months' use is as follows:

Total number of bundles delivered	2,700
Expense including storage, oil, parts and labor	$ 368.00
Tires and repairs	217.00
Gasoline	119.00
Registration	10.00
Wages	559.00
Total	$1,273.00

Depreciation, 33 1/3% per annum. Cost of delivering bundles by automobile, 6½c, by horse, 9 8/10c.

Four Overland delivery cars were used by the United States Mail Service at Indianapolis for eighteen months. Each car replaced three horse-driven wagons and covered sixty to seventy-five miles a day.

During the winter of 1910 in New York City a motor truck carried ten cubic yards of snow, as compared with five cubic yards carried by an ordinary contractor's wagon. The return trip from the unloading point to the dock took the motor truck on an average forty minutes, while the best record trip with a two-horse truck was one hour and twenty minutes. At the rate of 36 cents per cubic yard, the motor truck earned $7.20, while the best of its horse-drawn competitors earned $1.80. A New York contractor hauls heavy stone to the crusher and broken stone away from it. A 3-ton motor truck in one and a half days does the work that five teams took two days to accomplish.

In New York City a 5-ton truck delivered 963 tons of coal in twenty-six working days with no delay from breakdowns; it averaged twenty-eight miles per day and thirty-seven tons per day. A 10-ton truck delivered eighty-four tons a day and covered two and a half miles on each gallon of gasoline.

An industrial concern on Staten Island used one 3-ton gasoline truck, one 3-horse truck and one 2-horse truck over a round trip of twenty miles. The horse-drawn trucks made one trip each and the motor truck two trips per day. The 3-horse truck hauled 4½ tons at a cost of $10.03, the 2-horse truck hauled three tons

at a cost of $7.31. The motor truck hauled six tons at a cost of $13.40.

The Chicago Public Library has been using six 1-ton gasoline wagons to deliver books to their branches. They were installed in November, 1904, and the following statement was estimated to April, 1909.

Drivers' wages	$4,000.00	Machine work	$ 117.01
Gasoline	939.23	Parts replaced	1,304.02
Oil and grease	450.15	Tires	968.97
Parts	35.02	Waste	52.44
Painting	199.00	Supplies	210.78
Interest at 6%	1,080.00	Washing	600.00
Storage	800.00	Insurance	90.00
		Total	$10,846.62

Average miles per day, 33; average cost per ton mile, 18c.

This service formerly cost 20c per ton mile with horse drawn wagons.

The Manz Engraving Company replaced four double teams with one 3-ton truck which made two trips daily on a round trip of more than fourteen miles. Five gallons of gasoline were used per day.

In the Boston American Economy and Reliability contest, held in October, 1910, for motor trucks, the cost of gasoline and cylinder oil per ton mile ranged from $0.0068 to $0.0892 and for the twenty-eight cars the average was $0.026, with gasoline costing 16 cents and oil costing 50 cents per gallon.

Standard speeds for motor trucks were formally adopted at a convention of the National Association of Automobile Manufacturers held in 1912. Those speeds, as reported in the *Power Wagon* of Chicago are as follows:

TABLE 16

Load Rating	Miles per Hour	Load Rating	Miles per Hour
½ ton	16	4½ ton	9½
1 "	15	5 "	9
1½ "	14	6 "	8
2 "	13	7 "	7
2½ "	12	8 "	6
3 "	11	9 "	5½
3½ "	10½	10 "	5
4 "	10		

TYPES OF TRUCKS

There are several types of motor dump trucks for use by contractors and others who handle material in bulk. These trucks are so made that the body, together with its load of from three to ten tons, can be raised at the front end and the load slid out or else raised vertically to a sufficient height to permit chutes to be used. One of these trucks has a body that is raised at the front end by a pair of chains moved by a train of gears driven from the transmission set of the truck. Another is similarly operated, except that the chains are wound up on the

drums, which are worm driven from the primary shaft just back of the clutch.

There is also a dump truck that is operated by compressed air. A valve on the dash is opened to admit compressed air to a long vertical steel cylinder behind the seat. This raises a plunger whose rod is connected to the top of the front end of the body, thus hoisting the body with the load. Releasing the air from the cylinder allows the body to settle back to normal position. The compressor is operated by the vehicle engine. A new and valuable feature of some of the dump trucks are the automatic tail boards with which they are equipped. These are hung on trunnions at the top and so connected to a system of toggle arms at the lower corners that they open automatically as the front end of the body is elevated, thus enabling the driver to dump the load without leaving his seat. Upon lowering the body the tail board closes and is locked into position.

Besides the trucks suitable for general contractors' and builders' hauling, illustrated in Figs. 17 to 22A, there are a variety of trucks for special purposes, such as hauling lumber, refuse removal and for department purposes. In what follows I give such data as have been collected on the cost of motor truck operation.

COSTS OF MOTOR TRUCK OPERATION

Costs of motor truck operation specifically for contract work are somewhat rare, but they have been obtained in two cases which follow. Operating costs as compiled by manufacturers and as given for other lines of work than contractors' hauling are, however, nearly as serviceable, and a number of examples follow.

Manufacturers' Averages. From data made public by manufacturers and covering often several years of operation, the following averages have been compiled:

A tabulation compiled by one motor truck builder shows that the daily cost of a two-ton truck that averages 70 miles a day is $10.60; that of a three-ton machine averaging 62 miles a day, $12.20; of a four-ton truck averaging 55 miles a day, $13.80, and of a five-ton truck averaging 50 miles a day, $15.

Another company has compiled a similar cost table covering a period of more than six years. This shows the average daily cost of running a one-ton truck to be $8.07, of a two-ton truck $10.25, a three-ton truck $11.30, five-ton truck $14.80, seven-ton truck $16.45 and of a ten-ton truck $18.50 a day. The figures given for the trucks of one to ten tons capacity include all items properly chargeable to the hauling service, both actual running expenses and overhead expenses. Drivers' wages are figured at $16 to $22 per week, gasoline at 12 cents a gallon, oil at 30 cents; garage at $225 to $300 a year; tires at $275 for a one-ton machine to $1,650 for a ten-ton truck; overhauling and general repairing at $300 to $550; depreciation at 15 per cent; interest at 5 per cent, and fire and liability insurance at $150 to $240 per annum.

One of the electric commercial vehicle companies furnishes the general average operating costs for the three models which it makes. Fixed charges on the delivery wagon amount to $303 a year for interest and depreciation on non-wearing parts; maintenance for maximum service to $389 a year, and garaging, including charging current to $108. This amounts to $800 a year, or $2.66 per working day, not including drivers' wages. At $15 a week, wages would bring the total daily cost to $5.16. On the same basis the total cost of running the light truck is $5.63 a day and that of running the heavy truck $6.91 a day. Larger and heavier makes of electric trucks cost from $7 to $8 a day to operate.

Contractors' Cost of Hauling Blasted Rock. The following data on motor truck work hauling blasted rock are furnished by the Charles P. Boland Company, engineers and contractors of Troy, N. Y. The contract called for the excavation and removal of 23,000 cubic yards of rock. The rock was blasted and hauled in two 3-ton trucks. These were equipped with patent dumping bodies and were used continuously, day and night shifts. The excavated material was hauled in some cases a distance of one and a half miles. The records show that these trucks carried about twice the amount usually hauled in a 1½-cubic yard dump wagon and made the trip to the dumping ground and return in just half the time required for a team to make it. Experience proved that it was necessary to keep the trucks continuously on the move in order to work them economically, and with this idea in mind large steel bottom dump buckets were used in loading the trucks; thus no time was lost in loading, as several buckets were full at all times and the operation of reloading the trucks took only the time required to hoist the buckets over the trucks. The actual loading operation required but a few minutes.

In the hauling of materials from the freight house to the building site, the records show that hauling cement cost about 1½ cents per bag, or 30 cents per net ton. Eighty bags were carried on each trip and eight trips were required to unload a car containing 640 bags. Increased efficiency was obtained by having at least six laborers to do the loading, as little time is lost if the loading force is large enough. The average record of each car of cement from the freight house to the site of operations, a distance of about 1½ miles, was as follows:

6 Laborers, 6 hrs. each day, at 16c	$5.76
1 Chauffeur, 6 hrs. each day, at 25c	1.50
Fuel, oil, etc.	.55
Percentage of maintenance charge	1.00
Total	$8.81

Referring to their experience on this work the contractors write as follows:

In the care of an automobile truck, our experience has taught us that it is economical to keep every part well lubricated at

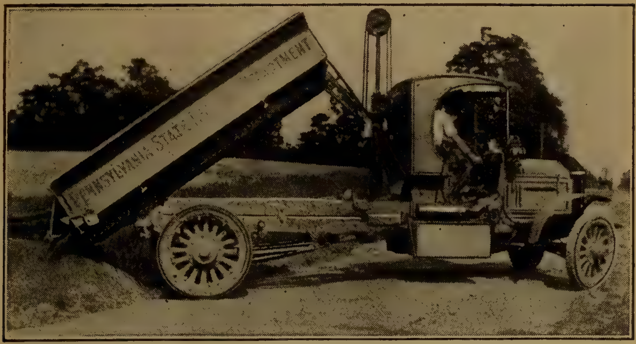


Fig. 17. Pierce-Arrow 5-Ton Truck with Hydraulic Hoist.

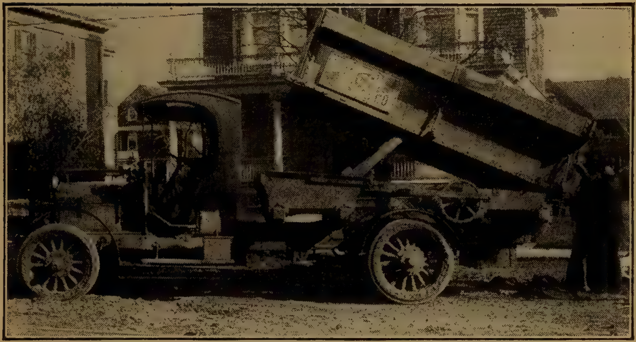


Fig. 17A. Pierce-Arrow 5-Ton Truck, High Level Tipping Body.

Fig. 18. Packard Dump Truck.

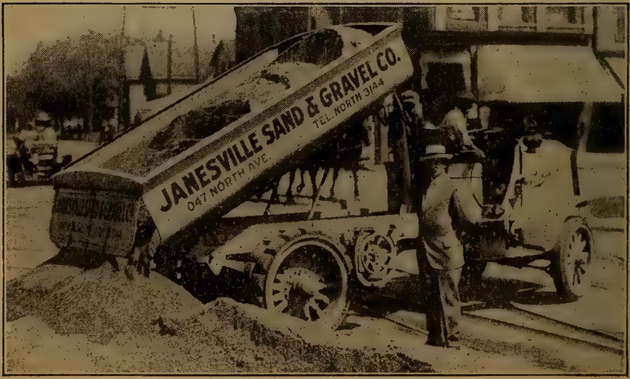


Fig. 18A. Packard 5-Ton Dump Truck.

Fig. 19. White 3-Ton Truck.

Fig. 19A. White 5-Ton Truck.

Fig. 20. Mack 7½-Ton Automatic Dump Truck.

Fig. 20A. Saurer 6½-Ton Truck with Wood Hydraulic Hoist.

Fig. 21. Peerless 5-Ton Rear Dump Truck.

Fig. 21A. KisselKar 3½-Ton Truck with Hydraulic Hoist.

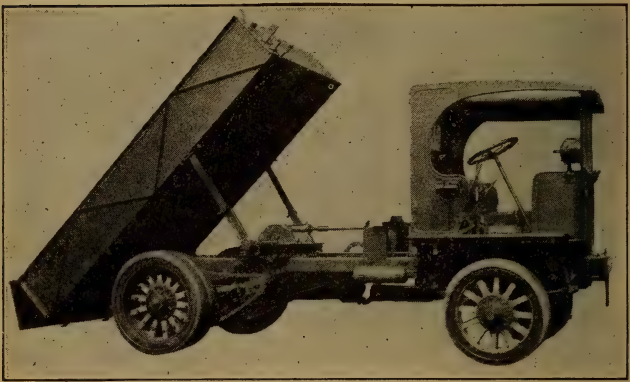


Fig. 22. Garford 5-Ton Dump Truck.

Fig. 22A. Knox Tractor with Trailer.

all times. A cheap or an inferior grade of oil should not be used, as the carbon forming qualities of a cheap oil more than offset the saving in the price. Where more than one truck is in use at least one chauffeur should be employed who is a thoroughly practical man. This will enable one to have each truck carefully looked over each day and any disarrangement corrected before damage is done. We have had little or no trouble with these trucks. The main expense in connection with the maintenance of the trucks is the wear and tear on tires. We are now using a wire mesh tire made by the Diamond Rubber Company which seems to give us good service. The company referred to sells these tires on a guaranteed mileage basis, and if renewals are necessary before the mileage is completed, a replacement is made by them and an adjustment made on the basis of the mileage obtained.

Owners' Reports on Costs of Motor Truck Operation. The following data on the cost of operating motor trucks are condensed from a paper by L. R. Dutton before the American Gas Institute:

Electric Trucks. One company reporting five 1-ton trucks (all of one make) one and one-half years old, one ½-ton truck, and one 2-ton truck, in use only a few months, furnishes the following operating costs. Total mileage of the seven cars, 39,507 miles:

Cost.	Total	Per mile
Battery man	$1,100.00	$0.028
Battery maintenance	595.71	0.015
Chains and sprockets	146.58	0.004
Chassis repairs	54.09	0.001
Current	282.38	0.007
Generating plant	133.21	0.003
Tires	591.06	0.015
Wagon repairs	17.00	0.000
Wagon washing	587.83	0.015
Miscellaneous	387.01	0.010
	$3,894.87	$0.098
Insurance	$ 539.90	$0.014
Battery maintenance accrued	984.57	0.025
Tires depreciation accrued	199.08	0.005
Depreciation at 10 per cent	2,054.00	0.052
Interest at 8 per cent	1,739.40	0.044
Total cost	$9,411.82	$0.238

The following figures are given on a 2-ton electric truck covering two years' service:

	Total cost	Cost per mile
Current at 2½ cts. per k-w h.	$ 253.88	$0.0275
Labor for maintenance	486.78	0.0528
Maintenance and repairs	1,130.04	0.1225
Total expense	$1,870.70	$0.2028

Miles traveled, 9,225.

This truck is reported out of service for maintenance in the two years, 12½ per cent of the working hours. The same com-

pany reports the following summary of expense on a 1,000-pound electric truck, covering a period of two and a half years' service—total mileage, 10,274.

	Total cost	Cost per mile
Interest on $1,668 at 6%	$ 250.20	$0.0244
10% depreciation on the value of wagon	244.20	0.0237
Maintenance and depreciation of batteries	601.02	0.0586
Tires and repairs	210.00	0.0204
Wagon expense, repairs	145.12	0.0142
Miscellaneous charges	48.54	0.0047
Total expense	$1,499.08	$0.1460

It will be noted that the owner of this vehicle suggests different depreciation values on various parts of an electric machine. He divides it as follows: First, depreciation on wagon; second, depreciation on tires; third, depreciation on batteries.

These expenses are complete, because the expense is included up to the point where the truck has a new set of tires, and is in good condition except that the wagon needs painting. It also had a new battery installed during the past year. Valuable information (Table 17) on the operation of electric vehicles can be obtained by consulting the Report of the Committee on Electric Vehicles, National Electric Light Association, June, 1911.

TABLE 17—COST OF OPERATING 1,500-LB. AND 3,000-LB. CAPACITY DELIVERY WAGONS.

Fixed Charges and General Expense	Average Cost — Per month	Total	Per mile. Cents
Drivers' salary	$ 65.00	$ 5,687.50	9.0
Supervision	5.22	456.75	0.7
Garage rent	5.18	453.25	0.7
Wheel tax	2.67	233.62	0.4
Washing, oiling, etc.	13.00	1,137.50	1.8
Interest at 5%, taxes at 1.5%, and insurance at .5% on total cost of wagon	14.58	1,275.65	2.0
Depreciation:			
Batteries, 66¾ per year on $255	14.17	1,239.87	2.0
Tires, 100% per year on $225.60	18.80	1,645.00	2.6
Balance of wagon, 10% per year	15.99	1,399.13	2.2
Total general expense and fixed charges	$154.61	$13,528.27	21.4
Total supplies and repairs	29.44	2,575.44	4.0
Grand total expense	$184.05	$16,103.71	25.4

Gasoline Cars. The following is the cost of operation of three 30 horsepower cars used by superintendents and managers of a gas company. They cost, new, somewhat less than $2,000 each.

TABLE 18

	1st Car. 9,474 Miles. 2⅛ Yrs. Use Total cost	Cost per mile	2d Car. 11,600 Miles. 1½ Yrs. Use Total cost	Cost per mile	3d Car. 15,651 Miles. 2⅛ Yrs. Use Total cost	Cost per mile
Gasoline ...	$109.66	$0.012	$106.75	$0.0092	$154.60	$0.010
Oil, etc....	6.28	0.001	20.85	0.0001	34.27	0.002
Tires	168.17	0.017	186.49	0.0161	243.48	0.016
Repairs ...	68.63	0.007	90.62	0.0078	76.43	0.005
	$352.74	$0.037	$404.71	$0.0332	$508.78	$0.033

One company reports the use by salesmen of three cars costing $750 each. Being low-priced cars and covering only from 500 to 800 miles per month, the depreciation was high. The amount charged for depreciation was the actual amount, because the cars were sold at the end of the year and the loss was known. The operating expense on the first car was 4.8 cents per mile; on the second, 10 cents per mile; on the third, 10½ cents per mile. If these cars were used by only one salesman it would indicate that the cost was unusually high.

A well-known company in another line of business, having salesmen in various parts of the country, furnished fourteen of its men with runabout cars costing $1,000 each. The cars average four months' operation; mileage of car 3,830. Item of expense: Gasoline, oil and grease, repairs to motor, depreciation, 25 per cent per annum. Total cost per mile, 14.9 cents.

Gasoline Trucks, 1,000 Pounds Capacity. Cost of operating five 1,000-pound trucks of a well-known make, costing $750 each, with large wheels and solid tires:

	Mileage	Cost per mile
Truck No. 1	2,000	0.0926
Truck No. 2	9,210	0.042
Truck No. 3	8,160	0.045
Truck No. 4	3,565	0.045
Truck No. 5	3,924	0.045

The cost of the above trucks include gasoline, oil and grease, tire repairs and sundries. The average is very uniform, except with car No. 1, the additional expense originating from a broken motor caused by an inexperienced driver learning to operate. The different companies operating these trucks all state that the depreciation cost is very high. In most cases the truck can only be kept in use a few months or a year and traded in for a new one. At least 50 per cent depreciation should be charged the first year. A practically similar experience was reported by a company with a truck of the same capacity and low cost, built by a different concern.

One Ton Trucks. Three companies report on the use of 1-ton trucks of different makes. Company No. 1 reports on two 1-ton trucks; total mileage, 18,550; cost per mile, 10 cents. This includes gasoline, oil, tires and motor repairs. The opinion of the owner is that the depreciation is 33 1-3 per cent per year. Com-

pany No. 2 reports on three 1-ton trucks. The report covers gasoline, oil, tires and repairs. The owner estimates depreciation 15 per cent. Truck No. 1, 6,060 miles; cost per mile, 11 cents; truck No. 2, 6,300 miles; cost per mile, 10½ cents; truck No. 3, 8,000 miles; cost per mile 8.6 cents.

Company No. 3 reports on the operation of one 1-ton truck. The expenses on 2,600 miles are as follows:

	Total cost	Cost per mile
Gasoline, at 11 cts. per gal.	$ 34.05	$0.013
Oil, at 50 cts. per gal.	8.45	0.003
Tires (accrued)	48.00	0.018
Repairs, none.		
Total	$ 90.50	$0.034

The item of tires mentioned above was owing to the rear tires being too light. They were removed and 1 inch heavier solid tires installed, at the above cost. The motor is of the two-cycle type.

One and One-half Ton Trucks. Only one company has reported on a truck of this capacity and similar make. The report covers a total of 11,150 miles and the truck was in use fourteen months.

	Total cost	Cost per mile
Gasoline, at 15 cts., 7 mill. per gal.	$ 236.70	$0.0212
Oil, at 35 cts. per gal.	35.00	0.0031
Tires and repairs	150.00	0.0134
	35.10	0.0031
Total expense	$ 456.80	$0.0408

The owner believes 12½ per cent depreciation should be charged on this truck. Its makers have reports from the owners of hundreds of these cars and claim the operating costs to average 8 cents per mile, made up as follows: Five per cent interest on investment; depreciation, 25 per cent; gasoline, oil, tires, motor repairs and maintenance, 70 per cent.

Two Ton Trucks. From the reports received only three companies are using the same make. One of the three furnishes detailed costs of operation, which report is very complete. Truck was owned fourteen months, or 352 working days; days in use, 227; days idle for repairs, 75, or 21 per cent. The owner reports that, although this car has been on the market for several years, an unusual amount of time was lost because of poor service rendered by the manufacturers and agent, owing to delays in obtaining repair parts. When parts were received they either did not fit the machine or were not perfect. Time lost was due as follows, in days: To springs, 5; to tires and wheels, 13; to motor, 33; to transmission, 15; to radiator, 9. The mileage was 11,300; gallons gasoline used, 2,250, or 5 miles per gallon; miles traveled daily, 41. A summary of the operating expense of this truck is shown as follows:

	Total cost	Cost per mile
Gasoline	$ 298.23	$0.0265
Oil	100.41	0.0089
Tires and repairs	432.98	0.0384
Car repair and sundries	370.22	0.0328
Labor, cleaning, etc.	514.27	0.0456
Total	$1,716.00	$0.1522

Standing Expense.

Insurance	$ 68.29	$0.006
Depreciation, 2% month	653.90	0.058
	$2,438.30	$0.216

It should be noted in connection with this truck that a common fault was found of installing tires under capacity on the rear wheels. The wheels also were too light for the load, owing to the overhang of pipe and poles from the rear of the truck. When the proper equipment was installed it was found that good service was received. The same difficulty was experienced with the springs, but they were changed to heavier type. It would appear that this make of truck would prove very satisfactory, after taking care of the usual difficulties experienced, by having it properly equipped for the work to be performed. The second year's operating should prove much more economical.

Three Ton Trucks. Carefully compiled figures show that 3-ton trucks, covering 40 miles a day, and operating 300 days a year, can be maintained and run at an average cost of $9.75 per day. The items making up this charge of an establishment of ten trucks, three tons capacity, are:

Wages, 10 drivers at $2.50	$25.00
Wages, repairmen, helper and washer	7.00
Gasoline, 80 gals. at 12 cts	9.60
Lubricant, 1 ct. per mile	4.00
Maintenance, 10% per year	10.00
Superintendence	3.20
Incidentals, light, heat, tools, etc	2.87
	$61.67
Average running expense per truck	$ 6.17
Interest at 6%, depreciation at 20%, insurance at ½%, all on $3,000	2.65
Storage, 200 sq. ft. at 50 cts. per year	0.33
Add 20% for 2 spare machines	0.60
Total operating and maintenance cost per day	$ 9.75
Total operating and maintenance cost per mile	0.24½

The tabulated cost of four 3-ton trucks, four years old, operating forty miles per day in Chicago follows. Each truck saves $9 per day on horses formerly used:

Standing Expense

	Per day.	Per mile.
5% interest on $3,500	$0.58	$0.015
Insurance	0.28	0.007

Running Expense

Gasoline, 10 gals. at 11 cts	$1.10	$0.027
Oil and grease	0.57	0.015
Tires and general repairs	2.00	0.050
Machine cleaning	1.31	0.32
Total	$5.84	$0.14

Five Ton Trucks. Only two companies report on 5-ton trucks. These have both been in use a year and the exact cost has been ascertained. The trucks are manufactured by different concerns. The operating costs are shown as follows:

First 5-Ton Truck

	Total cost	Cost per mile
Gasoline, at 15 cts. $0.033 mile per gal	$ 300.00	$0.05
Oil, at 35 cts. per gal	105.00	0.0175
Tires	260.00	0.0434
Maintenance and repairs	87.36	0.0145
Total expense	$ 752.36	$0.1254

Annual mileage 6,000 miles=per day 22 miles.

It is interesting to note that the owner of this truck states it has depreciated only 5 per cent, and that the truck performs the same work as a horse equipment costing $14.15 per day.

Second 5-Ton Truck

	Total cost	Cost per mile
Gasoline, 3 mile per gal. at 10 cts	$ 350.00	$0.034
Oil, at 55 cts. per gal	140.00	0.013
Tires	798.00	0.076
Repairs and maintenance	1,400.00	0.133
Total expense	$2,688.00	$0.256

Annual mileage 10,500 miles=35 miles per day.

It is interesting to note that the owner of this truck estimates 24 per cent depreciation. The worm drive which has been adopted by builders of motor vehicles abroad is installed in this truck. Very little attention has been given to it by American builders, although the housing of the worm drive in the rear construction, its simple design, easy lubrication, and noiseless running, should favor its high efficiency and long life.

The following was abstracted from the Oct. 5, 1912, edition of the *Electrical World:*

Electric Trucks. A study of the cost of operation of battery-propelled trucks was carried out by the Waverly Company, Indianapolis, Ind., some time ago, comparisons being made for vehicles of 600-lb., 1,500-lb. and 2,500-lb. carrying capacity. In these figures it was assumed that the 600-lb. car would travel 40 miles per day, or 12,000 miles per year, and the 1,500-lb. and

2,500-lb. cars 30 miles per day, or 9,000 miles per year. The cost of repairs and renewals given in the table was computed on a ten-year life of the car, and all parts were charged at regular list prices. The cost of batteries and tires was estimated at market price to the customer, although no account has been taken of the labor item of putting them on.

For the purpose of the calculation, batteries and tires were figured at one year's life, and gears, chains and sprockets at two years (gears, four years; bearings, four years; driving gears, exposed, one year; driving chain, one year). Electrical energy has been charged for at 4 cents per kw-hr., and rent, light, heat, etc., are estimated at $1 per square foot. The depreciation allowed is based on writing off that part of the vehicle not covered by maintenance in ten years. Interest is computed at 6 per cent of one-half of the purchase price, as the investment is being written off. Under these conditions the conclusions shown in the accompanying table were reached:

	600-Lb. Capacity, 40 Miles per Day, 12,000 Miles per Year.	1,500-Lb. Capacity, 30 Miles per Day, 9,000 Miles per Year.	2,500-Lb. Capacity, 30 Miles per Day, 9,000 Miles per Year.
Battery	$ 190.00	$ 216.90	$ 232.00
Tires	120.00	129.06	173.20
Chains, gears, etc.	28.37	77.91	85.00
All other parts	22.50	30.00	33.00
Total replacement charges	$ 360.87	$ 453.87	$ 523.20
Electric energy	$ 176.00	$ 156.00	$ 163.00
Garage labor	224.00	224.00	224.00
Driver	750.00	750.00	750.00
Rent, light, heat, etc.	72.00	77.00	78.00
Total operating expense	$1,222.00	$1,207.00	$1,215.00
Depreciation	$ 125.59	$ 147.91	$ 172.99
Interest	54.00	61.50	72.00
Fire insurance	18.00	20.50	24.00
Liability insurance	75.00	100.00	100.00
Total fixed charges	$ 272.59	$ 329.91	$ 368.99
Grand total	$1,855.46	$1,990.78	$2,107.19
Per day	6.18	6.63	7.02
Per mile	0.15	0.22	0.23

Electric Vehicle Data. Mr. Louis A. Ferguson gives the following figures in *Electrical World:* Number of pleasure electric vehicles in Chicago, 2,000; number of commercial electric vehicles, 250; number of commercial electric vehicles probably sold in 1912, 200; total number miles streets, 2,978; number miles of paved streets, 1,652, of which 1,200 miles are in very good con-

dition. The cost of maintaining a 2,000-lb. commercial electric wagon, running 10,000 miles per year, divided up about as shown in the table.

COST OF MAINTAINING 2,000-LB. ELECTRIC WAGON

Expenditure	Cost per Mile	Per Cent of Total
General Expenses:		
Supervision, garage rent, wheel tax and state license	$0.018	12.2
Operating Expenses:		
Fixed charges (interest, depreciation, taxes and insurance)	0.040	27.10
Tires	0.025	16.90
Washing and minor repairs	0.024	16.26
Battery renewals	0.019	12.90
General repairs	0.011	7.44
Electricity	0.0106	7.20
	$0.1476	100.00

Ton-mile delivery costs, horses and electric vehicles: The following data, taken from *Electrical World,* bearing on the comparative cost of ton-mile haulage by horses and electric vehicles were obtained by a prominent electric truck manufacturer from installations in New York City. The 1,500-lb. delivery service cited was that of a large department store; the 2-ton service included general merchandise delivery, usually in units of medium size, and the third class, 5 tons, covered the delivery of larger cases of similar material over a wide area. The figures given in the table include the stabling of the horses required to haul a truck of the stated size.

CLASSIFICATION OF SERVICES

	—1,500-Lb.—		—Two Tons—		—Five Tons—	
	Horses	Electric	Horses	Electric	Horses	Electric
Miles per day	17	30	16	30	12	24
Ton-miles per day	12.75	22.50	32	60	60	120
Cost per day	$6.00	$6.00	$6.37	$8.50	$9.10	$11.00
Cost per mile	0.35	0.20	0.52	0.28	0.76	0.45
Ton-mile cost	0.466	0.207	0.26	0.14	0.15	0.09

These figures bear out the contention that the electric truck gives a greater service and at a lower cost than is possible with horse-drawn equipment. The figures represent practically the limit of the horse, but they do not indicate the maximum possibilities of the electric truck, the mileage of which often runs considerably higher than in the figures presented. The data above given include all expenses and charges, with energy at 4 cents per kw-hr.; chauffeur's wages at $15 per week; writing off the investment in eight years; payment of 6 per cent interest meanwhile, with insurance and taxes, and one renewal of battery plates and tires yearly.

Trucking Costs. The following figures show the comparative

costs of running three double-truck teams and a four-ton motor truck, which replaced them. It will be noted, says the *Iron Trade Review*, that no depreciation is figured on the horse trucks. The motor truck at first ran 484 miles per month, consuming 7.6 gallons of gasoline, and two gallons of oil per day.

THREE DOUBLE TRUCKING TEAMS

Cost of six horses at $300	$1,800
Cost of three wagons at $450	1,350
Cost of six harnesses at $35	210
Cost of keeping horses, $25 a month	1,800
Repairing harnesses, wagons, etc.	100
Interest on investment	336
Drivers' salaries, $12 a week	1,872
Total, horses	$4,008

"KISSEL-KAR" FOUR-TON TRUCK

Cost of 4-ton truck	$3,800
Gasoline, 2,400 gals. a year at 10c	240
Oil, 156 gals. a year at 23c	36
Driver's salary at $18 a week	936
Amortization, 10 per cent on $3,800	380
General overhaul, once a year	150
Interest on investment	380
Total, truck	$2,122

COST AND SERVICE RECORDS FOR MOTOR TRUCKS

The following information is from *Engineering Record*, April 12, 1913.

5-Ton Trucks. The City Fuel Company, of Chicago, has in service fourteen 5-ton Saurer trucks. The records for November, 1912, as furnished by the International Motor Company, of New York, show that during that month these trucks ran 9,893 miles and carried 12,444 tons. Each truck worked an average of 25.3 days, covered an average daily distance of 27.92 miles, and hauled an average of 35.13 tons per day. The following gives the costs in detail:

	Total Cost	Average Cost per Truck	Cost per Ton
Gasoline	$ 431.76	$ 30.84	$0.0346
Lubricating oil	54.79	3.91	0.0044
Wages of helper and driver	1,247.95	89.14	0.1002
Other labor—loading, mechanics and repair men	245.60	17.54	0.0197
Repair parts and material	146.17	10.44	0.0117
Garage	140.00	10.00	0.0112
Light and power	3.64	0.26	0.0002
Insurance—Fire	58.38	4.17	0.0046
Insurance—Liability	143.34	10.24	0.0115
Miscellaneous expenses	39.14	2.80	0.0031
Tires	396.52	28.32	0.0318
Depreciation, 20 per cent	979.81	69.99	0.0788
License	42.00	3.00	0.0033
	$3,929.10	$280.65	$0.3151

The following was abstracted from an article published in *Engineering and Contracting*, Vol. 35, No. 5:

Passenger Automobile Operating Costs. The following table gives the actual cost of running a four passenger automobile, of the so-called demi-tonneau type, in the vicinity of New York City from July 4, 1909, when it was bought new, to Dec. 4, 1910, when it was laid up for the winter. The car is of a well-known make, and there was practically no engine trouble; it has a 4-cylinder engine, 25.6 h.p. A. L. A. M. rating, shaft drive. Of the 17 months the car was in commission it was in use for driving 15 months. It is estimated that of the total distance driven, namely, 8,500 miles, about two-thirds was over so-called good roads, varying from fair to very good. It was used mostly for pleasure, but somewhat for inspection trips to engineering works, when it received some hard usage. The writer estimates that if it had been used for business, under similar conditions, and driven, say, 15,000 miles in the same length of time, items 1, 5, 9, 10 and 11 would be unaffected, though, of course, item 5 is a very uncertain quantity, and might involve the total destruction of the car. Column 3 has been added to the table to show this estimated cost per mile on this basis. The car was driven by the owner, who had had no previous experience in driving, and it was kept at a public garage. It may be noted that no expense is included for additional wearing apparel or for extra expenses at hotels, restaurants, etc., when touring or on all-day trips, though these items are not inconsiderable and really enter into the cost.

ACTUAL COST OF RUNNING A FOUR PASSENGER AUTOMOBILE FOR 15 MONTHS NEAR NEW YORK CITY.

			Total Cost	Actual Cost per Mile.	Estimated Cost per Mile on Basis of 1,500 Miles.
	Original cost of car new	$1,500.00			
	Accessories	272.85			
		$1,772.85		Cents	Cents
1.	Less present value	700.00—Depreciation	$1,072.85	12.622	7.152
2.	New tires		128.85	1.516	1.516
3.	Tire repairs		62.30	.733	.733
4.	Ordinary repairs and adjustments		50.45	.593	.593
5.	Repairs on account of accidents		36.80	.433	.245
6.	Gasoline		125.58	1.480	1.480
7.	Oil and grease		19.35	.227	.227
8.	Batteries and dry cells		4.40	.052	.052
9.	Miscellaneous garage charges, etc		15.05	.177	.177
10.	Storage and cleaning, 15 months		225.00	2.647	1.500
11.	Insurance, fire and accident liability		143.50	1.688	.956
12.	State licenses		7.00	.082	.047
	Totals		$1,891.13	22.250	14.678

Notes in regard to the above items: Item 1. Depreciation: The makers of the car offer $650 cash for it as it stands now, this being their regulation price for 1909 cars, irrespective of condition; that is, of course, within reasonable limits. To put the car in shape to run another season will cost approximately $500, this including complete overhauling, new parts where necessary, four new tires and painting, and at the end of this season it would hardly bring more than $300 or $400, so that the depreciation charge is not too high.

Items 2 and 3: The tires used were 33x4. Including the four tires on the car when it was bought, seven shoes and nine inner tubes have been in use, of which there now remains only one shoe in fair shape and two or three inner tubes which may be used for spare next season. The writer believes the tire expense to be lower than usual. This item increases very rapidly and in much greater proportion as the weight of the car increases, and also is liable to be more on an old car in which some of the parts of the running gear become worn and pressures are not evenly distributed.

Item 4: This item is largely for small repairs and adjustments which might have been made almost entirely or at least half of them by the writer, except for the fact that he did not consider it economy to spend his time in this way, or to get as dirty as would have been necessary had he done so.

Items 6, 7 and 8: It will be noticed that these items for fuel and oil amount to a very small proportion of the total.

Item 9 is for tips to employes at the garage, and charges for greasing and oiling the car. The writer usually made a point of examining the car all over about once every two months, and at these times greasing everything up, but this took not less than five or six hours and used up a whole Saturday afternoon, so that in between times this work was done at the garage.

Item 10: This included washing the car and polishing the brass work as well as storage. This item can of course be cut down where the car is kept in one's own garage. Washing and polishing in this case if done at a public garage costs about $1 each time for a moderate sized car. If the car is run all winter, however, as this car was, the garage must be heated.

Item 11: This covers a period of two years.

AXES

Net prices at Chicago for axes are as follows:

TABLE 19

	Weight Lbs	Price each	Price per doz
Single bitted	3½ to 4½	$0.50	$5.35
Single bitted	4 to 5	.55	5.75
Single bitted	5 to 6	.65	6.50
Double bitted	4 to 5	.85	8.50

Handled axes bring the following net prices:

	Each.	Doz.
Single bitted, Michigan pattern, 4 to 5 lbs.	$0.80	$ 8.25
Single bitted, Michigan pattern, 5 to 6 lbs.	.90	9.00
Double bitted, Michigan pattern, 4 to 5 lbs.	1.10	11.00

BARGES AND SCOWS

Wood Barges. The following data are vouched for by Mr. C. W. Dunham (*Professional Memoirs*), and were published in *Engineering and Contracting*, July 17, 1912. They cover a very interesting and instructive record of initial cost, repairs and life of various classes of floating plant used on the Upper Mississippi Improvement during the last thirty years.

During this period of thirty years, this improvement has owned and employed 282 barges (scow), 12 barges (model), 90 quarter-boats, office-boats and store-boats, 3 steam drill-boats, 4 dipper dredges, 5 hydraulic dredges, 7 pile drivers, 23 dump boats, 3 snag-boats, 16 tow-boats of various sizes, and a very large number of small steam and gasoline launches, motor and ordinary skiffs, pontoons, and other small pieces.

It will not be practicable within reasonable limits to follow the destinies of so many pieces, and therefore certain characteristic groups of various kinds are taken, from the experience of which conclusions may be drawn. Pieces built within the last few years are not considered. I would say that none of the pieces up to 1908 had any kind of wood preserver except, occasionally, Carbolineum Avenarius laid on with a brush, but during the past three years, 80 barges, 4 dumps, 3 dredges, 33 pontoons, and 3 quarter-boats have been built, of which most of the lumber in the hulls has been treated with creosote by the open tank or dipping process. Sufficient time has not elapsed to show the value of this treatment.

In 1911 we treated lumber in barge construction by a pressure process.

Scow Barges. The standard barges used in this district are 100x20x4½ ft. and 110x24x5 ft. in size.

The barges used in the earliest years of this improvement for carrying rock and brush, were mostly of smaller size than those at present employed, were built of white pine, and with calking and nominal repairs, gave good service for periods ranging from eight to eleven years.

Model Barges. Early in the improvement six oak model barges, 135x26x5½ ft., were built on the Ohio River, three by Howard, of Jeffersonville, Ind., and three by Cutting, of Metropolis, Ill. These barges, numbered 60-62 and 88-90, were built in 1882 at $3,500 each, and were not condemned until 1901, but for five or six years previous the repairs were very heavy. These barges were in use eighteen years.

TABLE 20—SMALL BARGES USED EARLY IN THE IMPROVEMENT. ALL BUILT OF WHITE PINE UNTREATED

No.	Size Ft.	Builder.	Where built.	Year.	Cost.	Longevity. Years.	Remarks.
1–8	80x16x4	Wilson	Prescott	1881	$560	9	With one exception, and that due to accident, these barges gave good service for 9 years, and several were used for carrying brush a few years longer.
10–12	65x16x4	Eckhardt	Davenport	1881	720	11	Gave good service for 11 years and brush service for several more.
20–24 36–39 47	81x16x4	Hired labor, U. S.	Clinton and Davenport	1881	...	9	Do.
25–35	66x16x4	Eckhardt	Davenport	1881	548	8–10	Do.
65–72	80x16x4	Do	Do.	1882	685	9	Do.
76–85	80x16x4	Diamond Jo	Dubuque	1882	660	8	Do.

TABLE 21—GROUP I

Built by Isherwood, Davenport, 1891; 100 by 20 by 4 feet, White Pine. Cost $770 each.

No.	Repairs. 1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Total.
15	$48	$51	$170	$278	$58	$ 52	$21	$3	Bad	Condemned	$681
19	0	0	104	8	58	169	2	Bad	Do.	Do.	341
37	48	51	152	26	60	152	16	Do.	Do.	Do.	505
44	0	14	32	0	60	63	91	Do.	Do.	Do.	260
78	0	0	0	0	59	46	Bad	Do.	Do.	Do.	105
96	0	0	32	0	59	0	0	Do.	Do.	Do.	91
114	48	23	220	0	60	149	0	3	Do.	Do.	503
117	0	29	185	0	58	131	49	0	Do.	Do.	452

With one exception (78) the good life of this group of barges was seven years. The large repairs on four barges were due to accidents, collisions, snags, etc.

TABLE 22—GROUP II

Built by Whitney, Rock Island, 1891; 100 by 20 by 4 feet, White Pine. Cost, $770 each.

No.	Repairs 1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Total.
1	$48	$51	$192	$29	$58	$167	$16	Bad	Bad	Condemned	$561
2	0	0	78	0	0	56	0	0	Do.	Do.	134
18	0	23	60	0	0	40	62	0	Do.	Do.	185
39	48	32	144	0	60	80	11	0	Do.	Do.	375
43	17	33	0	60	31	0	Bad	Bad	Do.	Do.	141
82	92	0	29	0	0	145	0	0	Do.	Do.	266
115	48	25	74	5	58	149	0	0	Do.	Do.	359
116	0	0	3	0	60	37	91	Bad	Do.	Do.	191

With one exception (43) the good life of this group was seven years.

TABLE 23—GROUP III

Built by Kahlke, Rock Island, 1892; 100 by 20 by 4 feet, Douglas Fir. Cost, $806 each.

No.	Repairs to Barges. 1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	Total.
143	....	$ 7	....	....	....	$ 2	$115	$ 66	$ 8	$406	....	$160	$ 32	$ 44	$ 93	$ 93	*	$1,026
144	....	50	....	....	$ 42	34	139	215	....	170	....	99	30	74	19	144	*	1,016
145	....	24	....	....	....	37	124	200	8	144	....	122	19	47	98	116	*	939
146	....	100	....	....	16	155	220	115	....	300	$ 16	143	30	78	*	....	....	1,173
148	....	108	....	....	8	90	160	155	....	215	....	151	90	126	*	....	....	1,103
149	....	87	$ 15	....	6	82	40	64	....	276	....	8	50	**	*	....	....	628
150	....	107	....	....	15	101	134	83	30	430	***	....	....	....	....	....	....	900
151	....	78	28	....	20	140	137	188	....	279	41	189	174	10	*	....	....	1,284
152	....	100	....	....	24	70	55	190	150	489	....	50	170	25	*	....	....	1,323

Longevity fifteen and sixteen years, with deck repairs and partial rebuilding. *Condemned. **Bad. ***Wrecked.

TABLE 24—GROUPS IV AND V

Built by Batchelder, Stillwater, 1894; 100 by 20 by 4 feet, Douglas Fir. Cost, $800 each.

No.	Repairs to Barges 1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	Total.
168	....	....	....	....	....	$ 38	$ 17	$ 8	$352	....	$ 52	$32	$27	$ 93	$ 45	....	$36	$700
169	....	....	....	....	$ 33	....	91	8	326	....	56	16	26	90	37	$12	35	730
170	....	....	....	....	27	28	....	14	85	....	387	25	26	93	205	....	**	881
171	....	....	....	....	35	23	....	18	109	....	350	23	4	70	74	*	....	706
172	....	....	....	....	....	22	17	51	385	$10	53	55	25	....	10	72	34	734
173	....	....	....	....	....	33	30	....	234	76	52	16	18	....	12	57	36	564
†174	....	....	24	....	34	10	112	188	115	....	84	56	36	107	192	*	....	958
†176	....	....	....	$1	3	5	108	30	89	15	251	38	19	102	***	....	....	661
†177	....	....	....	....	10	110	204	....	75	....	422	14	21	*	....	....	....	856

Nos. 168, 169, 172 and 173 were partly rebuilt in 1902; 170 and 171 in 1904. All of these, except 171 and 173 are now (July, 1911) in fair condition. All of these went eight years with merely nominal repairs, such as calking. Repairs surprisingly small. *Condemned. **Fair. ***Bad. †Built by Kahlke, Rock Island, 1894; 100 by 20 by 4 feet. Fir. Cost, $806 each. Good life; twelve years, with nominal repairs and calking.

TABLE 25—GROUP VI

Built by Whitney, Rock Island, 1895; 100 by 20 by 4 feet; Fir gunwales, remainder White Pine. Cost, $790.

No.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904,	1905.	1906.	1907.	1908.	1909.	1910.	Total.
185	$18	....	....	$ 54	$193	$30	$ 85	$41	$50	$ 45	$ 1	*	....	....	....	$ 517
186	24	$10	....	102	17	18	73	....	....	47	63	326	$225	$445	†164	1,514
187	18	....	....	55	84	9	393	41	50	165	15	645	192	119	†3	1,789
188	....	14	$37	93	62	....	381	....	....	70	61	107	104	57	†56	1,042
189	....	4	91	100	125	24	309	41	50	155	35	625	161	*	...	1,720

† Fair. A good life, but repairs in later years large and perhaps unjustifiable. Three of these still in use, 1911. *Condemned.

TABLE 26—GROUP VII

Built by United States, Fountain City, 1895-1896; 100 by 20 by 4½ feet; Douglas Fir. Cost, $768 each.

No.	Repairs to Barges 1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	Total
192....	....	$35	$ 41	$68	...	$15	$ 88	$174	$114	$ 55	$ 49	$395	$145	$220	$276†	$1,675
193....	....	...	272	69	...	...	169	26	100	205	50	314	68	145	259†	1,677
194....	....	...	...	69	...	...	134	48	36	357	49	442	284	105	259†	1,783
196....	....	...	...	56	...	...	233	26	242	5	49	150	59	*	...	820
197....	....	...	87	28	$27	...	207	77	170	55	85	*	...	...	...	736
198....	....	...	...	24	...	...	181	45	51	259	107	188	39	*	...	894
199....	....	...	...	66	...	...	106	46	243	128	50	*	...	...	...	639
200....	....	...	42	64	...	15	159	26	38	5	**	*	...	...	...	349
201....	....	...	...	25	24	...	56	21	169	102	49	400	216	*	...	1,062

A good life, but repairs toward the end too large. Three still in use, 1911. *Condemned. **Bad. † Fair.

TABLE 27—GROUP VIII

Built by Brown, Quincy, 1892-1893; 100 by 24 by 4½ feet; Douglas Fir. Cost, $1,600 each.

No.	Repairs to Barges 1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	Total
153..	..	$31	$ 50	$ 7	$10	$ 61	$162	$312	...	$230	...	$ 86	$ 54	$33	$ 97	**	$1,133
154..	..	33	3	4	8	124	23	165	$153	101	$78	400	165	..	***	...	1,257
156..	..	18	2	...	92	*	...	...	...	...	...	...	...	..	...	...	....
157..	..	18	35	25	8	121	23	151	144	70	78	400	165	35	60	***	1,333
158..	..	70	2	3	49	156	18	150	147	78	78	397	290	9	7	***	1,454
159..	..	34	2	4	14	156	23	168	192	51	78	400	231	5	...	***	1,358
160..	..	34	2	10	14	153	23	159	126	76	78	397	200	5	26	***	1,294
161..	..	18	8	..	14	63	160	317	...	182	...	96	69	41	118	***	1,086
162..	..	17	159	..	..	74	144	380	...	211	...	104	73	57	124	***	1,343

*Wrecked. **Rebuilt. ***Condemned.

Several of these barges were partly rebuilt and all had new decks. No. 153 rebuilt and in use, 1911.

TABLE 28—GROUP IX

Built by United States at Keokuk, 1894; 110 by 24 by 5 feet; Douglas Fir. Cost, $1,400 each.

No.	Repairs to Barges 1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	Total
4	$20	$88	..	$ 2	$17	*$327	..	$ 74	...	$173	$ 33	$35	$ 79	**	....	$ 848
7	..	..	..	33	72	169	$ 3	*200	...	178	39	19	89	**	....	802
70	..	..	..	..	..	24	49	*337	$41	250	...	99	116	***	....	916
179	..	1	$2	..	44	21	13	*362	41	250	90	100	97	$47	****	1,068
180	..	1	2	22	5	16	42	*375	41	50	127	86	87	****	....	854
181	..	1	2	22	5	33	49	*325	41	250	98	104	59	10	***	999

*New deck and partly rebuilt. **Rebuilt. ***Bad. ****Condemned.

TABLE 29—GROUP X

Built by United States at Le Claire (C. W. D.). 1885; 120 by 20 by 5 feet. White pine with oak bottom, planked fore and aft. Cost, $1,300 each.

No.	Repairs to Barges 1885-90	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	Total
97	....	$ 90	$159	$47	*$1,229	$172	....	....	$101	....	$100	$29	$308	$80	$391	$105	$49	....	**	$2,860
98	....	132	16	10	.....	*901	....	....	....	$106	216	5	160	..	225	27	18	95	**	1,911
99	....	64	...	64	*949	18	....	....	34	114	355	...	206	9	....	31	18	115	**	1,977
100	....	83	...	222	54	....	....	$ 14	70	....	....	**	....	..	....	...	...	....	..	443
101	....	171	159	31	*1,082	*394	....	30	6	74	46	...	217	82	365	165	49	....	**	2,871
102	....	139	159	31	*1,034	....	....	210	6	6	34	...	218	79	334	178	49	....	**	2,523

*Rebuilt; life 21 years, once rebuilt. **Condemned.

These were the best barges used in this improvement. Cost of repairs and building large, but justifiable.

TABLE 30—RECAPITULATION. SCOW BARGES

Group	Number Barges	Dimensions Feet	Material	Cost Each	Yrs. in Service Max.	Yrs. in Service Min.	Yrs. in Service Av.	Repairs Max.	Repairs Min.	Repairs Av.	Remarks
I	8	100x20x4	White pine.	$ 770	8	6	7¼	$ 681	$ 91	$ 367	Light loads for the last year or two.
II	8	100x20x4	White pine.	770	8	6	7½	561	134	277	Do.
III	8	100x20x4	Fir........	806	16	13	14¼	1,323	628	1,044	Wrecked barge omitted. Barges show great vitality. Principal repairs, new decks and calking.
IV	6	100x20x4	Fir........	800	17	15	16⅔	881	564	719	Great longevity, small repairs, all but two in fair condition, 1911.
V	3	100x20x4	Fir........	806	14	12	13	958	693	825	Not so satisfactory as III and IV.
VI	5	100x20x4	Fir and pine	790	15	11	14	1,789	517	1,316	Very large and apparently unjustifiable repairs in the last four years. Three still in use and in fair condition.
VII	9	100x20x4¼	Fir........	768	15	9	12½	1,783	349	1,071	Built U. S. Three in fair condition, 1911; large repairs.
VIII	8	110x24x4½	Fir........	1,600	15	14	15	1,454	1,086	1,282	Wrecked barge omitted; long life with moderate repairs.
IX	6	110x24x5	Fir........	1,400	14	13	13⅓	1,068	802	913	Two of this group rebuilt in 1908. Built U. S.; good life, small repairs.
X	6	120x20x5	Pine with oak bottom	1,300	22	15	21	2,871	443	2,098	All but one rebuilt.

TABLE 31—DUMP SCOWS

Dimensions, 73 by 18 feet; eight pockets. Nos. 1 to 6, oak; Nos. 7 to 12, mostly **fir.**

			Repairs														Total	Good
No.	When Built	Cost	To 1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901				Repairs	Life
1	1885	$1,637	$690	$317	$98	Bad	Bad	Cond.	.....	....	....	....	.....				$1,105	8
2	1885	1,637	690	428	32	52	Bad	Cond.	.....	....	....	....	.....				1,202	8
3	1885	1,637	590	93	4	109	Bad	Cond.	.....	....	....	....	.....				796	8
4	1885	1,637	98	545	35	104	Bad	Cond.	.....	....	....	....	.....				782	8
5	1885	1,637	111	578	31	77	*1,359	.....	.....	138	....	....	Cond.				2,294	9
6	1885	1.637	555	149	30	Bad	Bad	Cond.	.....	....	....	....	.....				734	8
			1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910		
7	1896	1,192	30	8	27	115	220	150	*687	2	43	7	116	209	388	Cond.	2,102	6
8	1896	1,187	30	19	52	63	217	171	Cond.	....	....	....	.....	....	....	.....	552	6
9	1896	1,625	4	9	49	115	79	150	Cond.	....	....	....	.....	....	....	.....	406	6
10	1896	1,651	3	6	36	79	215	152	102	171	110	Bad	Cond.	....	....	.....	874	9
11	1896	1,651	....	....	....	2	28	338	*625	388	65	Bad	Cond.	....	....	.....	1,446	9
12	1896	1,636	....	....	....	....	28	329	*664	401	107	Bad	Cond.	....	....	.....	1,529	9

*Rebuilt. The rebuilding of No. 5 was not good policy. Nos. 7 and 8 used old irons. So much money for repairs on Nos. 11 and 12, 1902 to 1905, seems injudicious. The dump scows are of the usual side pocket type.

Steel Barges. Fourteen steel barges built for use on government work on the Mississippi River and placed in commission in 1912 are described in *Engineering and Contracting*, April 24, 1912. These barges cost $9,300 each, have a capacity of about 400 tons, and an estimated life of over twenty years. They are used in conjunction with creosoted wood barges of about the same capacity, but costing half as much and with an estimated life of ten years. It will be well to compare these estimates of life with those of Mr. Hageboeck, described later.

The steel barges are 120 ft. long, 30 ft. beam, 7 ft. 4 ins. deep at center of hold and 7 ft. at sides. They are of steel throughout, flat bottomed, with rounded knuckles, wall sided, symmetrical about center line, with a rake 15 ft. long, a sheer 12 ins. high at each end, and a crown of beam 4 ins. There are four transverse water-tight bulkheads, and one non-water-tight longitudinal bulkhead over the center line, and two longitudinal trusses.

Untreated Wood, Treated Wood and Steel Compared. Mr. A. C. Hageboeck, United States Inspector at Rock Island, Ill., in a paper presented to the American Wood Preservers' Association, and reprinted in *Engineering and Contracting*, April 24, 1912, gives the comparative costs of barges of treated and untreated timber and of steel. He states that the life of untreated yellow pine barges is difficult to determine due to lack of accurate records, but that a barge containing a minimum proportion of sappy timber is past economical repairs at the end of ten years. Pressure-treated yellow pine barges have been used for twelve years and are good today for an additional life of ten years. It is necessary to recalk the barges after two years' service. The original cost of untreated barges, 120x30x6 ft. built in the early nineties was about $3,000, and the cost during ten years averaged $2,006.61 per barge. The original cost of pressure-treated yellow pine barges of the same size was $4,000, and the cost of repairs averaged $557.35.

The following table compares the two kinds of barges:

TABLE 32—COMPARATIVE ANNUAL COST OF TREATED AND UNTREATED YELLOW PINE BARGES

120 Ft.x30 Ft.x6 Ft.

	Untreated Barges, 10 Years Old	Treated Barges, 9 Years Old
Original Cost	$3,093.39	$4,000.00
Cost of Repairs	2,006.61	557.35
Total Cost	$5,100.00	$4,557.35
Value of Barges Today		$3,600.00
Cost of Barges During Total Periods	$5,100.00	957.35
Annual Cost Per Barge	510.00	106.00
Annual Saving in Favor of Creosoted Barge		404.00

Repairs to untreated fir barges are mainly due to decay and not to abrasions. The life of barges of this wood used on the upper Mississippi has been from ten to seventeen years, averaging fifteen. The cost of repairs is slight up to the sixth or seventh year, at which period $200 to $300 is spent for extensive repairs. After that time repairs average $75 per year until the tenth or twelfth year, when extensive repairs are again required and the barges have to be taken from rock work and placed in the brush carrying service. The life of treated fir barges is estimated at twenty years with slight repairs.

The following table is based on government freight rates on timber, and for commercial comparison, $10 per barge should be added to the yearly cost.

TABLE 33—COMPARATIVE COST OF LIGHT DRAFT BARGES BUILT OF VARIOUS KINDS OF MATERIAL

100 Ft. x 20 Ft. x 4 Ft. 7 Ins.

	—Douglas Fir—		—Yellow Pine—		Steel
	Untreated	Treated 10 Lbs.	Untreated	Treated 14 Lbs.	
	15 Yr. Lf.	20 Yr. Lf.	15 Yr. Lf.	22 Yr. Lf.	25 Yr. Lf.
Original Cost....	$1,200	$1,500	$1,300	$1,650	$4,000
Total Repairs...	1,094	400	1,094	700	400
Interest at 5% on Cost	900	1,500	975	1,815	5,000
Interest at 5% on Repairs	341	125	341	125	125
Total Cost...	$3,535	$3,525	$3,710	$4,290	$9,525
Annual Cost Per Barge	$236	$177	$247	$195	$381
Annual Saving in Favor of Creosoted Fir Barge	59		70	18	204

Further data on the cost of barges are given by Mr. John L. Taylor in *Engineering News*, September 26, 1912, in which he takes exception to the price of steel barges given by Mr. Hageboeck above. He states that the following is an abstract of proposals for furnishing two gravel barges for Dam No. 28, Ohio River, opened on November 23, 1911:

Barges 100 Ft. x 22 Ft. x 5 Ft.

Bidder No.	Rate per Barge	Amount	Material
1	$3,680	$7,340	Untreated Wood
2	2,950	5,900	Untreated Wood
3	4,350	8,700	Steel
4	3,870	7,740	Untreated Wood
5	3,050	6,100	Untreated Wood
6	3,620	7,240	Untreated Wood

The above shows a ratio between the cost of a steel barge and a wooden barge of 1.47 to 1 in comparing the lowest price for a wooden barge, and 1.27 to 1 in comparing the average price of wooden barges.

Bids opened on January 24, 1912, for two dump scows for the same work were as follows:

Barges 80 Ft.x21 Ft.x6 Ft. 4 Ins.

Bidder No.	Rate per Barge	Amount	Material
1	$6,490	$12,980	Untreated Wood
2	6,565	13,130	Untreated Wood
3	5,895	11,790	Untreated Wood
4	6,700	13,400	Steel

The above shows a ratio between the price of steel and lowest price of wood barges to be 1.14 to 1 and between the price of steel and average price of wood barges to be 1.06 to 1.

Bids opened October 7, 1910, at St. Louis, Mo., resulted as follows:

Flat Barges, 55 Ft.x16 Ft.x3 Ft.

Bid No. 1, Lowest Bid for Steel Flat Boats............$1,725 each
Bid No. 2, Lowest Bid for Wooden Flat Boats.........1,223 each
The cost ratio is 1.41 to 1.

Miscellaneous Boats. Mr. C. W. Dunham in *Professional Memoirs,* reprinted in *Engineering and Contracting,* gives the following information in regard to quarter boats of pine or fir:

Quarter Boats. The quarter boats used in this improvement, in which category may be included office-boats and inspection boats, have been very numerous and always long lived, because it has been advisable to rebuild hulls or provide new ones on account of the cabins, which do not decay or wear out. The dimensions and design of these boats have varied—in fact, it is believed that there are hardly any two alike.

Building boats have not been standardized, although those recently built are quite similar. Many of these boats were adapted from ordinary barges. They are used in building dams, being suspended along the line of the dam; the brush and rock barges are handled with their power.

TABLE 34—QUARTER BOATS. HULL, PINE OR FIR. CABINS, PINE

No.	When Built	—Dimensions— Hull, Ft.	Cabin, Ft.	Cost With Outfit	Material of Hull	Remarks	Repairs and Outfit to Dec. 31, 1910	Condition, Dec. 31, 1910	Life Yrs.
75	1882	75x20x3	*60	†$ 700	Pine	1882-1891 no repairs; hull rebuilt 1894 and 1907; large repairs 1898 and 1909.	$4,319	Fair	28
118	1891	70x20x3	*55	1,414	Pine	Large repairs 1897, 1899, 1902, 1905, 1907; new hull 1910, fir.	3,205	Good	19
47	1894	75x20x3	60x19	1,561	Pine	Nominal repairs to 1908 when hull was rebuilt.	1,628	Good	16
71	1894	75x20x3	60x19	1,138	Pine	Nominal repairs to 1904; large repairs 1905-1907; hull rebuilt 1909.	2,763	Good	16
183	1895	100x20x3	80	2,698	Pine	Nominal repairs to 1909, when hull was rebuilt.	3,199	Good	15
184	1895	60x18x3	45	871	Pine	Nominal repairs to 1910, when hull was rebuilt.	1,558	Good	15
202	1895	70x20x3	55	1,328	Pine	Nominal repairs to 1907, when hull was rebuilt.	2,269	Fair	15
11	1893	75x20x3	60x19	1,648	Pine	Nominal repairs to 1910, when hull was rebuilt.	2,206	Good	16
65	1893	40x16x2	30x16	416	Pine	Nominal repairs to 1907, when hull was rebuilt.	698	Good	16
94	1884	60x16x3	.....	250	Pine	Small repairs to 1902, when hull was rebuilt; new hull in 1910.	1,429	Fair	26
91	1884	60x16x3	.....	452	Pine	Small repairs to 1895, when hull was rebuilt; new hull in 1905.	1,400	Fair	26
121	1892	52x16x2½	40x12	430	Pine	Small repairs to 1903, when hull was rebuilt; new hull in 1910.	1,197	Good	28
122	1892	52x16x2½	40x12	430	Pine	Small repairs to 1903, when hull was rebuilt; new hull in 1910.	1,198	Good	28
123	1892	52x16x2½	40x12	430	Pine	Small repairs to 1903, when hull was rebuilt; new hull in 1908.	848	Fair	28
124	1892	52x16x2½	40x12	430	Pine	Small repairs to 1903, when hull was rebuilt; new hull in 1908.	1,027	Good	28

TABLE 34—QUARTER BOATS. HULL, PINE OR FIR. CABINS, PINE—Continued

No.	When Built	—Dimensions— Hull, Ft.	Cabin, Ft.	Cost With Outfit	Material of Hull	Remarks	Repairs and Outfit to Dec. 31, 1910	Condition, Dec. 31, 1910	Life Yrs.
20	1897	64x18x3	50x18	1,452	Fir	Small repairs to 1905, when hull was rebuilt.	982	Good	13
67	1893	66x18x3	46x18	1,727	Pine	Small repairs to 1907, when hull was rebuilt.	2,831	Good	17
69	1893	50x16	38x16	607	Pine	Hull partly rebuilt in 1904; small repairs in other years.	994	Good	17

*A good part of the expense attached to these boats is in the renewal of outfit.
†The cost of No. 75 seems small, but it does not include outfit.

TABLE 35—BUILDING BOATS

Nos. 36 and 38, Hand-Power Capstans; No. 64, Steam Power

No.	When Built	Dimensions of Hull, Ft.	Material of Hull	Cost	Remarks	Con-demned	Total Repairs	Good Life
36	1893	120x18x3	Pine	$1,385	Nominal repairs to hull and machinery to 1907.	1908	$ 975	14
38	1893	120x18x3	Pine	1,385	Nominal repairs to hull and machinery to 1902. Bad from 1903 to 1908	1908	586	9
64	1895	160x26x4	Fir	3,786	Nominal repairs for four years; large repairs 1902 to 1908	1908	2,709	13

Hulls of building boats were not rebuilt, the capstans, etc., being transferred to new and improved hulls.

BARS

Net prices for solid steel crowbars, lining bars, claw bars, and railroad tamping bars, are about as follows:

	Per Lb.
Crowbars	4 cts.
Lining Bars	4 cts.
Claw Bars, Goose Neck	6 cts.
Claw Bars, With Heel	6 cts.
Railroad Tamping Bars	4½ cts.

BAR BENDERS

The steel bar bender shown in Fig. 23 takes round, square or channel iron up to ½ in. size and flat iron 1½x⅜ in., 2¼x$\frac{5}{16}$ in.

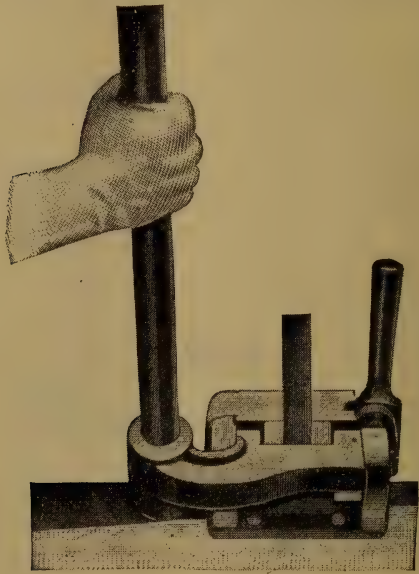


Fig. 23.

or less, cold, weight 35 lbs., price $25. Figure 24 illustrates a steel bar bender for cold steel bars, round, square or twisted from

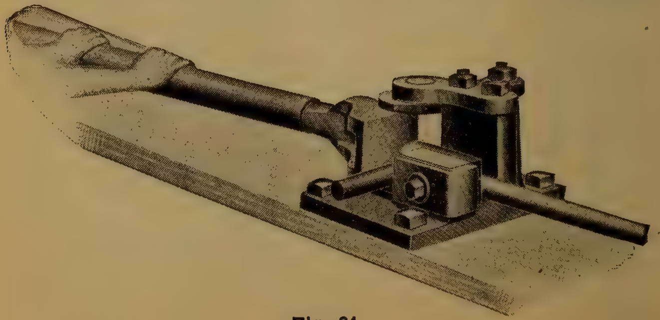
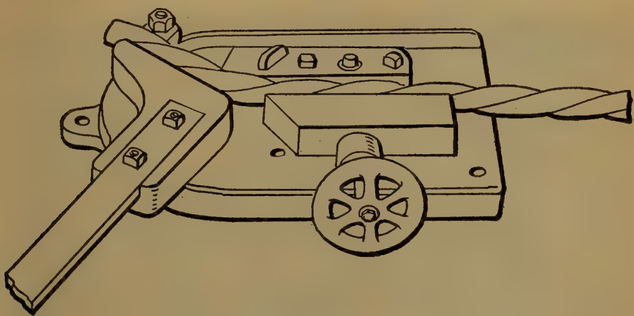


Fig. 24.

¼ in. to 1⅜ in., weight 175 lbs., price $58. Both of these machines will bend to any angle and are fastened by bolts to a plank or beam and operated by one or more men.

A very strong bar bender is shown in Fig. 25. This machine is constructed entirely of steel and is bolted to any suitable plank



Patented.

Fig. 25. Acme Bar Bender.

or beam. It is adapted to any size bar by turning the hand wheel and to any curve by loosening one nut; weight 200 lbs., price $85.

A large portable machine mounted on a truck is illustrated in Fig. 26. It will bend rods of mild or high carbon steel

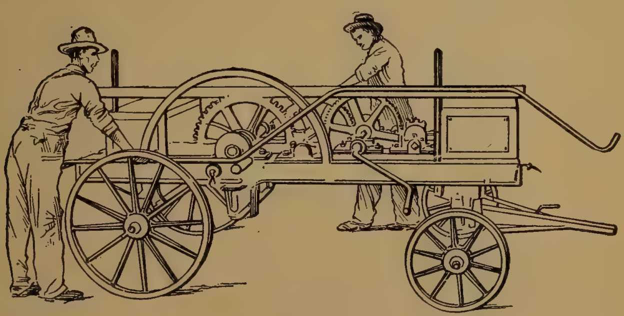


Fig. 26.

varying in diameter from ¼ to 1½ in. to any angle within the limits of the shearing resistance of the metal. The machine is operated by one to three men. In a test made in 1909 rods of mild steel 1⅛ in. in diameter for use in the "Mushroom" system of reinforcing, were run through the machine continuously for

one hour. In that time 205 rods were bent to the required shape. This machine is 10 ft. long by 2 ft. 6 in. wide and the weight is about 1,800 lbs., price $500.

A bar bending machine particularly designed for bending stirrups is illustrated in Fig. 27. The Turner Construction Com-

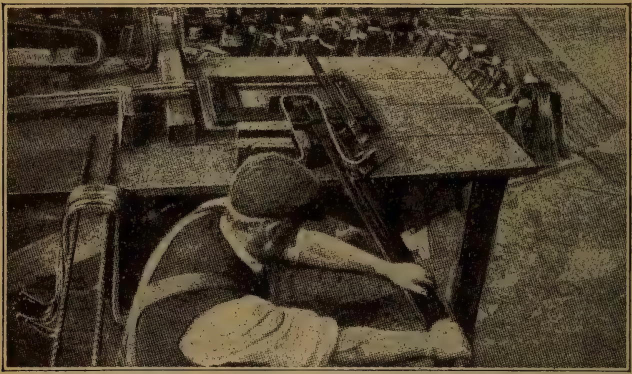


Fig. 27.

pany states that a metallic lather, in eight hours, would bend from 300 to 500 stirrups per day, while with this bender they found it easily possible to bend from 1,200 to 2,000 stirrups per day. The price of the machine is $50, f. o. b. New York.

BAR CUTTERS

A cutter which is operated by a lever and takes twisted steel bars up to ¾″ in size, weighing 190 lbs., costs $85. A machine which takes bars up to 1¼″, weighing 195 lbs., costs $160.

A machine which cuts flat bars 2½″ wide and square bars 1⅛″ wide, costs $60. Machines for cutting rods from ⅛″ to ½″ in diameter cost from $5 to $8.

BELTING FOR POWER PURPOSES

Leather. Price per 1-inch width per running foot in cents: Single, 9½ cts.; Double, 19 cts.; Triple, 28 cts. Weight, 16 oz. to 1 sq. ft. in single ply.

Round Leather. Price per ⅛-inch width per running foot in cents: Solid, 1½ cts.; Twist, 2 cts.

Cut Lacings, bundles. Price per ¼-inch width per 100 ft., 60 cts.

Rubber. Price per 1-inch width per running foot in cents.

2-ply	3½ to 4½ cts.	6-ply	7½ to 9½ cts.
3-ply	4½ to 5 cts.	7-ply	9 to 11½ cts.
4-ply	5½ to 6 cts.	8-ply	10½ to 13 cts.
5-ply	6½ to 8 cts.		

The price increases as the width.

Stitched Canvas. Price per 1-inch width per running foot.

4-ply	3 cts.	8-ply	6 cts.
5-ply	4 cts.	10-ply	7½ cts.
6-ply	4½ cts.		

Detachable Link Belts. We give below a table of various sizes of detachable link belt with prices, etc. Figure the working strain at one-tenth the ultimate strength for speeds of from 200 to 400 feet per minute. For lower speeds increase this by two-thirds. When a number of attachment links for fastening on buckets, etc., are used, add about 15 per cent to cost of chain.

TABLE 36—COST AND STRENGTH OF LINK BELT DETACHABLE CHAINS

Chain No.	Price per Ft.	Number of Links in 10 Ft.	Width in Inches	Ultimate Strength
25	$0.04	133	¾	700
32	.04	104	$\frac{15}{16}$	1,100
33	.04	86	$\frac{15}{16}$	1,190
34	.04	86	1$\frac{1}{16}$	1,300
35	.04	74	1⅛	1,200
42	.05	88	1$\frac{3}{16}$	1,500
45	.04	74	1¼	1,600
51	.07	104	1⅛	1,900
52	.07	80	1$\frac{7}{16}$	2,300
55	.06	74	1$\frac{5}{16}$	2,200
57	.07	52	1$\frac{11}{16}$	2,800
62	.09	73	1$\frac{9}{16}$	3,100
66	.09	60	1¾	2,600
67	.09	52	1$\frac{5}{16}$	3,300
75	.10	46	2	4,000
77	.10	52	2⅛	3,600
78	.14	46	2½	4,900
83	.14	30	2$\frac{15}{16}$	4,950
85	.18	30	3$\frac{13}{16}$	7,600
88	.17	46	2½	5,750
93	.20	30	2⅞	7,500
95	.21	30	4⅛	8,700
103	.27	39	3$\frac{1}{16}$	9,600
105	.20	20	4$\frac{1}{16}$	6,900
108	.26	25½	4⅝	9,900
110	.30	25½	5$\frac{1}{16}$	12,700
114	.34	37	3$\frac{5}{16}$	11,000
122	.45	20	5½	15,000
124	.42	30	3⅞	12,700
146	.41	20	5¼	14,000

BINS

Portable Mounted Bin. Three-pocket 25-ton (rated capacity) mounted bin of selected lumber; steel lined bottom; equipped with steel chutes.

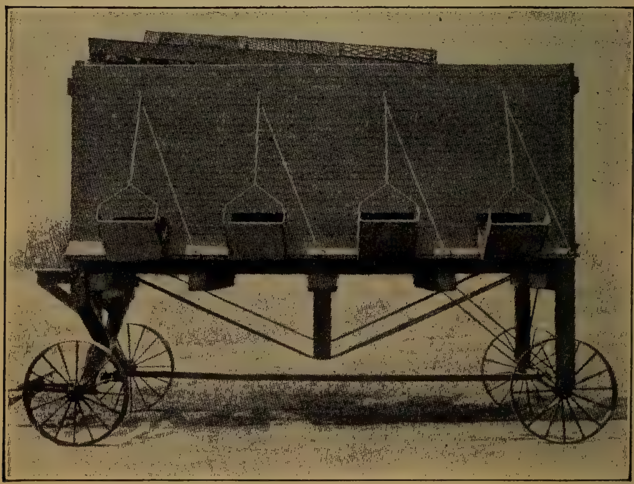


Fig. 28. 15-ton Bin with Screen Lowered.

	Price
Arranged for lowering screen into bin	$270.00
Arranged for lowering bin only	281.25
Arranged for lowering screen and bin	337.50

BLACKSMITH SHOP OUTFIT

Tools necessary for a blacksmith shop suitable for drill and general repair work are about as follows in an ordinary shop:

1	anvil, 130 lbs.	$ 13.00
2	augers, ship, 1⅞", $1; 1-1", $1.20	2.20
2	bevels, universal	2.50
1	brace and 13 auger bits, ¼" to 1", in roll	5.50
1	caliper, micrometer	6.00
4	calipers, spring, at $1	4.00
6	chisels, cold, 12 lbs. at 50c	6.00
4	chisels, hot, 8 lbs., at 50c	4.00
1	cutter for pipe up to 3"	4.80
1	drill, stationary, hand power, ¼" to 1¼" hole, weighs 170 lbs.	22.00
1	drill, breast	3.00
6	drill dollies	10.00
24	files, assorted, at $8 per doz	16.00
24	files, flat, at $8 per doz	16.00
12	files, small taper	.60
24	files, triangular, at $7 per doz	14.00
1	grind stone, foot power, 3"x12" wheel	4.00
1	gauge, marking	2.00
4	heading tools, 1½ lbs. each	3.00
3	hammers, blacksmith	2.70
3	hammers, set	1.50
4	handies, at 50c per lb.	2.00
2	pails at 70c	1.40
6	rasps, at $12 per doz	6.00
1	rule, 6 ft., folding	.40
1	saw, cross-cut, hand, 26"	1.35
1	saw set	.70
2	saws, haok, at $1	2.00
4	shanks	2.00
1	sledge, double face, 5 lbs	1.50
2	sledges, double face, 7 lbs. each	4.20
1	sledge, cross pein, 5 lbs	1.50
2	sledges, cross pein, 4 lbs. each	2.80
2	squares at $9	18.00
1	stock and 8 dies for ½" to 2" pipe	17.50
8	swedges, bottom, 1 lb. each	2.00
8	swedges, top, 1 lb. each	2.00
9	tongs, assorted	12.00
1	vise, blacksmith's leg, 6¼"	20.00
1	vise, hinged, for pipe, ⅛" to 3"	3.15
		$243.30

BLASTING MACHINES

TABLE 37

Brand	Maximum Capacity	Weight Gross	Weight Net	Price	
Du Pont Pocket Battery*	3 Electric Fuses	5 lbs.	2½ lbs.	$ 2.50	Two post only
No. 0	4 Electric Fuses	13 lbs.	9 lbs.	12.50	Two post only
No. 2 Reliable	10 Electric Fuses	25 lbs.	20 lbs.	10.00	Two post only
No. 3 Reliable	30 Electric Fuses	30 lbs.	25 lbs.	15.00	Two post unless specially ordered with three posts
No. 3 U. S. Standard	30 Electric Fuses	30 lbs.	25 lbs.	15.00	
No. 4 Reliable	50 Electric Fuses	50 lbs.	45 lbs.	30.00	Three post unless specially ordered with two posts
No. 4 U. S. Standard	50 Electric Fuses	50 lbs.	45 lbs.	30.00	
No. 3 Pull Up	30 Electric Fuses	40 lbs.	33 lbs.	15.00	Two post unless specially ordered with three posts
No. 4 Pull Up	50 Electric Fuses	60 lbs.	45 lbs.	30.00	Three post unless specially ordered with two posts
No. 5 Pull Up	100 Electric Fuses	65 lbs.	50 lbs.	45.00	

The maximum capacity indicates the number of electric fuses the blasting machines will fire when using two posts and two leading wires. When three posts and three leading wires are used the maximum capacity is increased 50 per cent. When iron wire fuses are used the maximum capacity of all blasting machines is only one-sixth of the capacity shown above. This does not apply to the use of iron wire electric fuses with the Du Pont Pocket Battery.

*The Du Pont Pocket is a small dry cell blasting battery for use where it is desired to fire not over three electric fuses when the cells are new.

BLASTING SUPPLIES

(See also Explosives)

BLASTERS' THAWING KETTLES

	No.	Capacity, Lbs.	Gross Shipping Weight, Lbs.	List Price
"Bradford"	1	22	25	$4.75
"Bradford"	2	60	30	7.25
"Catasauqua"	1	30		4.75
"Catasauqua"	2	60		7.25

The price of "Bradford" is net: of "Catasauqua," 10% discount. F. o. b. distributing points east of Montana, Wyoming, Colorado and New Mexico.

BLASTING AUGERS

Augers may be conveniently used to bore holes for inserting dynamite under tree stumps, etc. They cost as follows:

	Inches	List Price
*Dirt	1½	$1.25
*Dirt	2	1.35
*Dirt	2½	1.50
Wood	1½	1.75
Wood	2	2.25
Wood	2½	2.75
Auger Handles		1.25

*Without handles.
F. o. b.: Cincinnati, O., Pittsburgh, Pa., Indianapolis, Ind.

BLASTING CAPS

TABLE 38

Brand	No.	Weight of Charge Grains or Grammes		List Price* Per 1000 Lots of 1000 or Over	List Price* Per 1000 Lots of Less Than 1000
Silver Medal...	3	8.33	.54	$ 6.00	$ 6.25
Gold Medal.....	4	10.33	.65	6.50	6.75
Du Pont........	5	12.34	.80	7.00	7.25
Du Pont........	6	15.43	1.00	8.00	8.25
Du Pont........	7	23.15	1.50	10.00	10.25
Du Pont........	8	30.86	2.00	13.25	13.50

* The discount from above is about as follows:

In lots less than 20,000 at factory, net.
In lots of 20,000 or over delivered, 10%.

Caps are packed in the following size cases without extra charge.

Case 0..................................	500 caps to the case
Case 1..................................	1,000 caps to the case
Case 2..................................	2,000 caps to the case
Case 3..................................	3,000 caps to the case
Case 5..................................	5,000 caps to the case

BLASTING FUSE

The price list of fuse given below is subject to about the following discounts:

In lots of less than 1000 ft.	2½ to 10%
In lots of 1000 to 5000 ft.	7½ to 15%
In lots of 6000 ft. and over	17½ to 25%

depending on the section of the United States where it is sold.

TABLE 39

Kind of Fuse and Use	Price per 1000 Ft.	Packed in Barrels, Ft.	Cases, Ft.
Hemp, for use in dry ground	$3.05	.....	12,000
Cotton, for use in dry ground	3.55	.....	12,000
Superior Mining, for hard tamping	3.75	8,000	6,000
Beaver Brand, for use in wet ground	3.90	8,000	6,000
Single Tape, for use in wet ground	4.05	8,000	6,000
Anchor Brand, White Finish, for use in very wet ground	4.65	8,000	6,000
Crescent Brand, White Finish, for use in very wet ground	4.65	8,000	6,000
Reliable Gutta Percha, for use in very wet ground	4.65	8,000	6,000
Double Tape, for use in very wet ground	4.85	8,000	6,000
Stag Brand, White Finish Gutta Percha, for use in very wet ground	5.60	8,000	6,000
Special No. XX, Gutta Percha, semi-smokeless and almost free from lateral emission of sparks	5.60	8,000	6,000
Triple Tape, for use in very wet ground and will bear rough treatment	5.70	7,000	6,000
Special No. XXX, Gutta Percha, designed to be even freer from smoke and sparks than Special No. XX	6.70	8,000	6,000

The packages weigh approximately:

	Barrels, Lbs.	Cases, Lbs.
Hemp and Cotton	135	135
Triple Tape	150	125
All Others	145	115

ELECTRIC FUSE

TABLE 40

(Copper Wires) List Prices per 100

Length of Wire Ft.	No. 4 (Single Strength) 10.03 Grains or .65 Gramme	No. 6 (Double Strength) 15.43 Grains or 1.00 Gramme	No. 7 23.15 Grains or 1.50 Grammes	No. 8 30.86 Grains or 2.00 Grammes
	Weight of Charge			
4	$ 3.00	$ 3.50	$ 4.00	$ 4.50
6	3.54	4.04	4.54	5.04
8	4.08	4.58	5.08	5.58
10	4.62	5.12	5.62	6.12
12	5.16	5.66	6.16	6.66
14	5.70	6.20	6.70	7.20
16	6.24	6.74	7.24	7.74
18	6.78	7.28	7.78	8.28

TABLE 40—Continued

Length of Wire Ft.	10.03 Grains or .65 Gramme	15.43 Grains or 1.00 Gramme	23.15 Grains or 1.50 Grammes	30.86 Grains or 2.00 Grammes
20	7.32	7.82	8.32	8.82
22	8.32	8.82	9.32	9.82
24	9.32	9.82	10.32	10.82
26	10.32	10.82	11.32	11.82
28	11.32	11.82	12.32	12.82
30	12.32	12.82	13.32	13.82

Longer lengths (made to order), $1.00 for each additional 2 feet.

The discount from above is about as follows:

5,000 or over, delivered	25%
1,000 or over, factory	15%
Less than 1000, factory	10%

Waterproof electric fuses cost about 30% more than the above. Electric fuses with iron wires cost about 15% less.

Electric fuses are packed as follows:

Length of Wires	Number of Fuses in Carton	Number of Cartons in Case	Total Number of Fuses in Case
4 ft. to 16 ft. inc.	50	10	500
18 ft. to 30 ft. inc.	25	10	250

BLASTING MATS

Mr. H. P. Gillette, in "Rock Excavation," says:

"**Use of a Blasting Mat.** For preventing accidents due to flying rocks, all blasts in cities should be covered either with timbers or with a blasting mat. This should be done to avoid suits for damages, regardless of city ordinances. A blasting mat is readily made by weaving together old hemp ropes, 1½ in. diameter or larger. To make such a mat, support two lengths of 1-in. gas

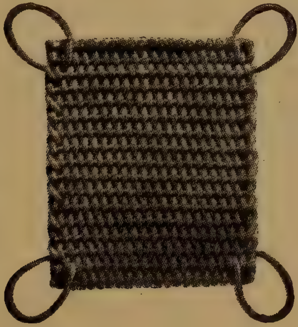


Fig. 29. Blasting Mat.

pipe parallel with one another and as many feet apart as the width of the mat is to be. Fasten one end of the rope to one end of the pipe; carry the rope across and loop it over the other

pipe; bring it back around the first pipe; and so on until a sufficient number of close parallel strands of the rope have been laid to make a mat as long as desired. Starting with another rope, weave it over and under, like the strands in a cane-seated chair, until a mat of criss-cross ropes is made. Such a mat, weighted down with a few heavy timbers, will effectually prevent small fragments from flying at the time of blasting. The mat and its ballast may be hurled into the air several feet, upon blasting; but it will serve its purpose by stopping the small pieces of rock which are so dangerous even where light blasts are fired. The mat should be laid directly upon the rock. Such a mat will save a great deal of labor involved in laying a grillage of timbers over a trench. It will also make it unnecessary for the blasters to stand far from the blast when firing."

Manufactured Mats. Close woven blast mats made of 1¼ in. diameter rope with a loop in each corner and binding on sides, can be bought new in New York for 80 cents per square foot; mats made of 1-in. diameter rope cost 70 cents per square foot. (Fig. 29.)

BLASTING WIRE

Connecting Wire. No. 20 B. & S. Gauge on 1-lb. and 2-lb. spools.

Leading Wire. No. 14 B. & S. Gauge both single and duplex in 200 ft., 250 ft., 300 and 500 ft. coils.

Leading wire reels	$4.00
Connecting wire holders	2.00

The price of wire varies with the locality, but is about as follows:

Leading wire No. 14	$24.00 per lb.
Connecting wire No. 20	29.00 per lb.
Connecting wire No. 21	31.50 per lb.

This is subject to the following discounts:

Less than 50 lbs., one sale, one delivery	10%
50 lbs., or over, one sale, one delivery	15%
100 lbs., or over, one sale, one delivery	25%

BLOCKS

TABLE 41—WROUGHT IRON GIN BLOCKS FOR WIRE ROPE, STIFF SWIVEL HOOKS AND BECKETS

Heavy Pattern, Phosphor Bronze, Self-Lubricating, Bushed

Diam. Sheave, Inches	For Rope Diam. Inches	Description	Price Each
10	⅝	Single	$ 5.50
		Double	9.00
		Triple	14.00
12	⅝	Single	6.25
		Double	10.00
		Triple	15.50
14	¾	Single	7.50
		Double	11.50
		Triple	18.00
16	⅞	Single	9.00
		Double	13.50
		Triple	23.00
18	1	Single	11.50
		Double	16.00
		Triple	26.50

TABLE 42—WROUGHT IRON BLOCKS FOR WIRE ROPE, HEAVY PATTERN WITH STIFF SWIVEL HOOKS

Diam Sheave at Bottom of Groove. (Ins.)	For Rope Diam. (Ins.)	— Iron Bushed —			Phosphor Bronze Metaline Self-Lubricating Bushed.		
		Single	Double	Triple	Single	Double	Triple
10	⅝	$ 7.00	$10.00	$14.00	$ 8.50	$13.00	$18.50
12	⅝	8.00	11.50	15.50	9.50	14.50	20.50
14	¾	9.00	12.50	18.00	10.50	15.50	22.50
16	⅞	15.50	20.00	23.00	18.00	25.00	32.50
18	1	17.25	22.50	30.00	20.00	28.00	37.50

TABLE 43—STEEL TACKLE BLOCKS, WITH SHACKLES

Size Sheave, (Ins.)	For Rope Diam. (Ins.)	Length in Ins. of Shell.	—Iron Bushed—			Phosphor Bronze or Metaline Bushed, Self-Lubricating.		
			Single	Double	Triple	Single	Double	Triple
6¼x1½x ¾	1¼	10	$ 2.16	$ 3.50	$ 4.59	$ 2.97	$ 5.13	$ 7.02
8 x1⅝x ⅞	1½	12	3.38	5.54	8.10	4.23	7.30	10.80
9½x1⅞x ⅞	1¾	14	4.86	8.10	10.80	5.94	10.25	14.04
12 x2⅝x1⅛	2¼	18	10.80	18.90	27.00	12.40	22.14	31.86

TABLE 44—TACKLE BLOCKS

Size Sheave (Ins.)	For Rope Diam. (Ins.)	Length of Shell (Ins.)	—Iron Bushed— Single	Double	Triple	—Bronze Bushed— Single	Double	Triple
4¼x1 x½	⅞	7	$0.29	$0.54	$0.79	$0.38	$0.76	$1.12
6¼x1¼x⅝	1⅛	10	.62	1.01	1.49	.79	1.35	1.91
8 x1⅜x¾	1¼	12	1.00	1.69	2.40	1.19	2.07	2.97
9 x1¼x¾	1¼	13	1.57	2.36	3.38	1.83	2.88	4.15
10 x1¾x⅞	1½	15	1.80	2.92	4.05	2.08	3.49	4.90

TABLE 45—LIGNUM VITAE SHEAVES FOR REGULAR AND THICK MORTISE BLOCKS

Size of Sheave, Ins.	Length of Block, Ins.	Iron Bushed, Price	Bronze Bushed, Price
4¼x1 x½	7	$0.21	$1.05
6¼x1¼x⅝	10	0.46	1.93
8 x1⅜x¾	12	0.63	2.06
9 x1½x¾	13	0.84	2.28
10 x1⅝x⅞	15	1.05	2.73

TABLE 46—IRON SHEAVES

Size of Sheave, Ins.	Length of Block, Ins.	Iron Bushed Self-Lubricating, Price	Bronze Bushed, Self Lubricating, Price
4¼x1 x ½	7	$0.20	$0.75
6¼x1¼x ⅝	10	0.35	1.12
8 x1⅜x ¾	12	0.57	1.48
9 x1¾x ¾	13	0.88	1.73
10 x1⅝x ⅞	15	0.97	1.95
12 x2⅝x1⅛	18	2.25	4.00

TABLE 47—WROUGHT IRON BLOCKS—ENGLISH PATTERN WITH STIFF SWIVEL HOOKS

Size of Sheave Ins.	For Rope Diam., Ins.	For Chain Ins.	Length Shell, Ins.	Iron Bushed Single	Double	Triple
4¼x1	⅞	..	7	$ 1.55	$ 2.30	$ 2.92
6 x1½	¼	$\frac{5}{16}$	10	3.10	5.25	6.75
8 x1⅞	1¾	$\frac{7}{16}$	14	5.25	10.00	13.50
10 x2⅝	2¼	⅝	18	14.25	21.50	29.25

Phosphor Bronze or Metaline Bushed, Self-lubricating

Single	Double	Triple
$ 2.18	$ 3.55	$ 4.80
3.92	6.90	9.25
6.30	12.10	16.65
15.87	24.75	34.12

TABLE 48—WROUGHT IRON SNATCH BLOCKS—ENGLISH PATTERN WITH STIFF SWIVEL HOOKS

Diam. Sheave, Ins.	For Rope Diam. Ins.	Iron Bushed	Phos. Bronze or Metaline Bushed
10	⅝	$ 9.60	$10.80
12	⅝	10.80	12.20
14	¾	12.00	14.40
16	⅞	16.80	19.80
18	1	22.80	26.40

TABLE 49—HEAVY TACKLE, THICK MORTISE BLOCKS, EXTRA HEAVY LOOSE SIDE HOOKS AND STRAPS

Diameter of Sheave, Ins.	For Rope, Diam., Ins.	Length of Shell	Iron Bushed			Bronze Bushed		
			Single	Double	Triple	Single	Double	Triple
4¼x1⅛x½	1	7	$1.12	$2.00	$ 2.75	$2.12	$ 3.75	$ 5.00
6¼x1½x¾	1¼	10	2.00	3.25	4.25	3.62	6.75	9.50
8 x1⅝x¾	1½	12	2.62	4.25	6.25	4.62	8.50	12.50
9 x1¾x¾	1½	13	4.00	6.50	8.50	6.50	11.75	16.50
10 x1⅞x⅞	1¾	15	4.50	7.50	10.00	....	.....	.....

TABLE 50—HEAVY TACKLE, THICK MORTISE BLOCKS, EXTRA HEAVY LOOSE SWIVEL HOOKS AND STRAPS

Diameter of Sheave, Ins.	For Rope, Diam., Ins.	Length of Shell	Iron Bushed			Bronze Bushed		
			Single	Double	Triple	Single	Double	Triple
4¼x1⅛x½	1	7	$1.42	$2.37	$ 3.20	$2.55	$ 4.37	$ 6.20
6¼x1½x¾	1¼	10	2.60	4.12	5.50	4.22	7.62	10.75
8 x1⅝x¾	1½	12	3.87	5.75	7.87	5.87	10.00	14.12
9 x1¾x¾	1½	13	5.62	8.25	10.75	8.12	13.50	18.75
10 x1⅞x⅞	1¾	15	6.25	9.75	13.00	9.25	15.50	21.50

BLUE PRINT FRAMES

BLUE PRINT FRAMES COMPLETE WITH POLISHED GLASS (Fig. 30)

Fig. 30. Print Frame on Wheel Carriage.

	20x24	24x30	30x42	36x48	36x60	42x60	42x72
With oak frame...	$10.75	$16.00	$27.75	$36.90	$44.25	$50.25	$63.00
With hardwood frame	10.00	14.50	23.50	33.15	39.75	.....	.....
With wheeled carriage	37.00	49.50	49.50	62.90	71.25	78.75	94.50
With mountings for window......	.....	.....	54.75	70.90	79.75	.....	.....
Same with revolving carriage	.....	.....	20.00	20.00	20.00	.....	.....

BLUE PRINT MACHINES

Continuous Blue Print Machine. Operated by single arc lamp using 15 amperes at 110 volts, or 7½ amperes at 220 volts, traveling up and down continuously in the center of a half cylinder of glass, while the paper and tracing are carried around by an endless canvas band. Speed can be regulated to 2 feet per minute using rapid paper. Size 2 ft. 6 in. square by 6 ft. high. Weight 400 lbs. Price, $300 f. o. b. factory.

Fig. 31. Continuous Blueprint Machine.

Another vertical machine of similar type uses lamps for direct or alternating current of 110 or 220 volts. It requires a floor space of 36"x42".

Catalogue Size	Two Print Surfaces, Inches	Price
1	42x36	$210.00
2	42x48	230.00
3	42x60	245.00
4	42x72	300.00

BOILERS

Upright tubular boilers constructed for 100 lbs. working pressure complete with base and fixtures cost as follows; f. o. b. manufacturer's works:

Rated H. P.	Weight, Lbs.	Price
4	2,500	$150.00
8	3,000	185.00
12	4,000	225.00
15	6,000	275.00
20	7,000	325.00
30	9,000	375.00
50	11,000	550.00

Locomotive type boilers mounted on wheels, complete, constructed for 100 lbs. pressure. The 70 H. P. is mounted on skids.

Rated H. P.	Weight, Lbs.	Price
10	4,000	$300.00
15	7,000	350.00
20	8,000	400.00
25	9,000	425.00
30	10,000	450.00
40	10,500	550.00
50	11,000	600.00
60	11,500	700.00
70	11,500	725.00

The outside of the boiler should be kept dry at all times and the inside of it should be as nearly free from scale and rust as possible. Different kinds of water will have different effects upon the life of the boiler, and the results to be obtained from it. In a limestone country the boilers will scale rapidly. This scale is a poor conductor of heat and as soon as it reaches a considerable thickness will cause a marked decrease in a boiler's steaming efficiency. In alluvial country, where the water contains much vegetable and loamy matter, the boilers will gather an accumulation of heavy mud and should be blown at least once each week.

Mr. John W. Alvord, of Chicago, gives a table showing the history of thirty-two horizontal tubular boilers used in water pumping stations in Illinois, Iowa and Michigan. The active life of these boilers was found to have ranged from six years for two boilers at Sterling, Ill., where artesian water was used, to twenty-three years for two boilers in Oskaloosa, Ia., where river water was used, the latter boilers being still in service. The average life of this group of thirty-two boilers was fifteen years. This would indicate that the rate of depreciation on boilers should be 20 per cent where artesian water is used, 10 per cent where lake water is used and 5 per cent where soft river water is used.

Estimating the Horsepower of Contractors' Boilers. A boiler is usually estimated to give one horsepower for every 10 sq. ft. of heating surface. Hence the horsepower of a vertical tubular boiler is found thus:

Rule: Divide the total heating surface of the tubes and fire box (expressed in square feet) by ten, and the quotient is the horsepower.

The square foot heating surface of a tube is quickly calculated by multiplying the length of the tube in feet by 0.26 and then multiplying by the outside diameter of the tube in inches. Since tubes are ordinarily 2 in., the total heating surface of the tubes is found by multiplying the number of tubes by their length in feet by 0.52; or, for all practical purposes, take half the product of the number of tubes by the length of tube in feet. To this heating surface of the tubes must be added the heating surface of the fire box, which is ascertained thus: Multiply the circumference of the fire box in feet by its height above the grate in feet and add the square foot area of the lower flue sheet.

The diameter of the fire box or furnace is usually 4 to 5 ins. less than the outside diameter of the boiler. The height of the fire box is usually 2 to 2½ ft. The amount of coal required for a contractor's boiler is about 6 lbs. per horsepower per hour, or 60 lbs. per horsepower per day of ten hours. Nearly one gallon of water will be required for each pound of coal. About 2⅓ lbs. of dry wood are equal to 1 lb. coal, or 2 cords of wood equal 1 ton of coal.

BOILER ROOM TOOLS

TABLE 51

Boiler room tools cost as follows:

Length	Diam. of Bar, Ins.	Price, Each: Hoe	Slice Bar	Clinker Hook	Poker
6	⅝	$1.20	$0.95	$1.20	$0.80
8	¾	1.80	1.50	1.85	1.30
10	⅞	2.50	3.00	2.80	2.00
12	1	4.60	4.60	4.40	2.80

Roller tube expanders, 1 in. to 6 in., $2 to $12

BOOTS

Boots are generally supplied by the contractor to his men where the work is of a wet nature. Good quality rubber boots cost from $3 to $5 per pair depending on the length of boot and the quality of the rubber. Unless shod with leather, they will wear out in from two to six weeks. Leather soles cost about 50 cents to 60 cents a pair put on, but are liable to cause the boots to leak. These soles double the life of the boot, but the best practice is to buy specially constructed boots with a sewed leather sole and heel. Short boots of this type cost $4.75 per pair, Storm Kings cost $5.60, and hip boots cost $6.50. Boots of this type last at least four times as long as the ordinary boot.

BRICK RATTLER

The city of Baltimore in 1909 installed a "rattler" for testing vitrified blocks. The machine is 28 ins. in diameter, 20 ins. long within heads. The barrel is a regular paragon of fourteen sides and contains about 12,018 cubic inches. It is driven by a 5 horsepower single phase electric motor making 1,710 revolutions per minute. The speed was geared down at the "rattler" end of the belt to produce thirty revolutions per minute. The cost of the outfit and the expenditures during the first year were:

One vitrified block rattler with belt	$192.50
One 5 H. P. motor	150.00
Cast steel shot	12.00
Freight and drayage	10.20
Building foundation and remodeling shed	53.32
One set scales	8.70
New cast-iron shot	10.20
One new pulley	5.20
One revolution counter	4.00
Electric installation	37.64
Electric company's connections	3.73
Electric current	5.69
	$493.18

BUCKETS

Contractors' buckets are of two general types: (1) that which is filled by hand, or other agency outside itself, and (2) that which fills itself by digging into the material to be conveyed. The first type of bucket as used by contractors, is usually a dump bucket, and the bowl is cleared by either tilting it, or allowing a door or gate in the bottom to open, thereby releasing the material. The second type of bucket is usually either clamshell or orange peel, but is sometimes made in special shapes.

The following table gives the approximate weights of materials commonly handled with buckets:

TABLE 52

Material	Weight per Cubic Yard, Lbs.
Dry sand	2,700
Wet sand	3,400
Loose earth	2,400
Wet clay	3,000
Anthracite coal	1,600
Bituminous coal	1,450
Crushed stone	3,000
Iron ore	4,200
Granulated slag	1,600
Gravel	3,000

Bottom dumping buckets similar to Fig. 32 cost as follows:

TABLE 53

Capacity in Cu. Ft.	App. Wt. Lbs.	Price
3	175	$ 45
7	360	56
10	450	66
12	500	73
14	575	84
18	650	91
21	745	98
27	850	105
34	1,025	128
41	1,150	140
54	1,650	185
63	1,700	196
67	1,775	203
75	2,070	210
85	2,300	227

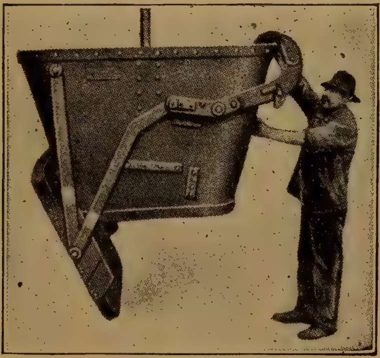


Fig. 32.

Coal tubs similar to Fig. 33 cost as follows:

TABLE 54

Capacity Coal, Tons	Cu. Ft.	Weight, Lbs.	Price
⅛	5	150	$18
¼	10	270	26
½	20	440	48
1	40	800	63
Long Ton	45	825	67

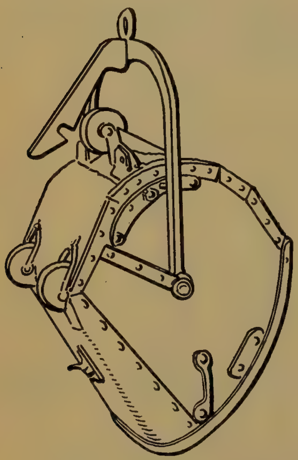


Fig. 33.

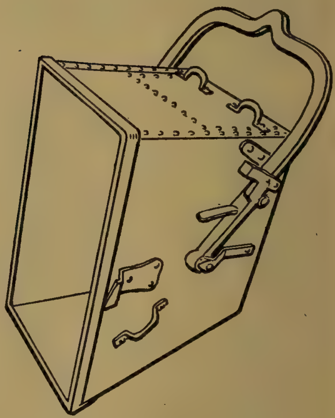


Fig. 34.

Contractors' tubs, Fig. 34, cost as follows:

TABLE 55

Capacity Cu. Ft.	Length, Ins.	Width, Ins.	Depth, Ins.	Price
3	26	28	15	$16
6	33	26	19	18
12	42	33	25	26
18	48	37	29	33
27	53	43	29	42
42	60	58	33	56

Contractors' and miners' round tubs, Fig. 35, cost as follows:

TABLE 56

Capacity Cu. Ft.	Length, Ins.	Width, Ins.	Depth, Ins.	Price
6	31	37	21	$16
14	44	49	25	28
21	48	56	30	36
27	50	60	34	44
42	58	71	40	60

Fig. 35.

Bottom dump buckets, similar to Fig. 36, cost as follows:

TABLE 57

Capacity, Yds.	Top Width	Bottom Width	Depth	Price
½	31	25	30	$ 48
1	41	32	37	60
1½	46	35	42	80
2	51	39	45	100
3	61	48	48	148

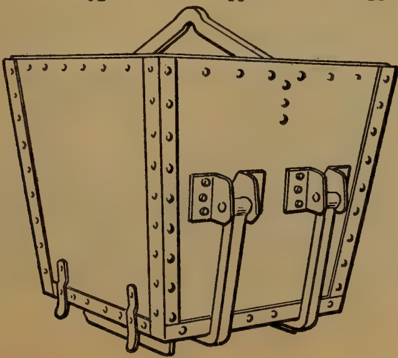


Fig. 36.

Center dump pier buckets for concrete, Fig. 37, cost as follows:

TABLE 58

Capacity, Cu. Ft.	Weight, Lbs.	Price
15	535	$ 71
22	590	90
30	875	103
36	925	117
45	1,140	130

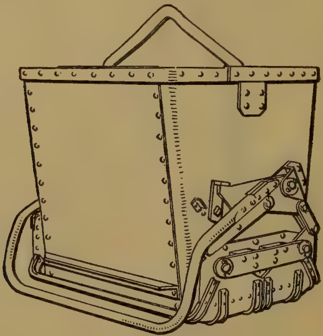


Fig. 37.

Center dump form buckets, for concrete, Fig. 38, cost as follows:

TABLE 59

Capacity, Cu. Ft.	Weight, Lbs.	Price
15	450	$ 81
22	550	94
30	775	108
36	850	121
44	950	135
60	1,000	161

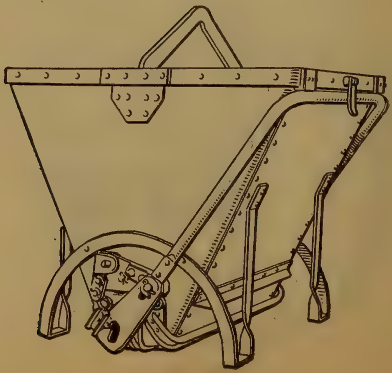


Fig. 38.

Lockwood Automatic concrete bottom dump buckets, cost as follows:

TABLE 60

Capacity, Cu. Yds.	Weight, Lbs.	Price
1	1,000	$100
1½	1,500	140
2	2,000	180
2½	2,200	200
3	2,400	220

CLAMSHELL BUCKETS

Class C, used for handling all classes of loose materials, fitted with round link side chains.

TABLE 61

Capacity, Cu. Yds.	Weight Lbs.	Dimensions, Open— Width, Ft.	In.	Length, Ft.	In.	Price
½	2,000	3	3	5	7	$ 357.50
1	2,350	3	3	7	6	487.50
1½	3,400	3	9	8	6	552.50
2	4,500	5	0	8	6	747.50
3	6,250	6	0	9	9	1,056.25
5	10,000	7	0	11	0	1,560.00

Class E, a very good digging bucket; suitable for handling crushed stone. Fitted with flat link side chains and strong cutting edge.

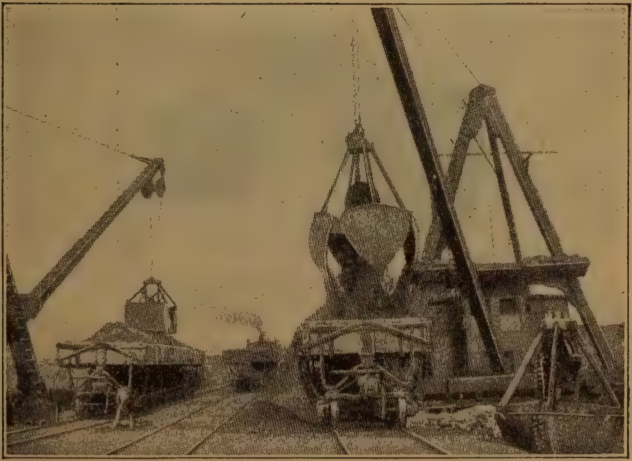


Fig. 39. Unloading Scows of Cellar Dirt for the Pennsylvania Railroad Embankment at Snake Hill, N. J.

TABLE 62

Capacity, Cu. Yds.	Weight Lbs.	Dimensions, Open — Width, Ft.	In.	Length, Ft.	In.	Price
½	2,100	3	3	5	7	$ 390.00
1	2,600	3	3	7	6	520.00
1½	3,800	3	9	8	6	617.50
2	4,750	5	0	8	6	780.00
3	6,500	6	0	9	9	1,105.00
5	11,000	7	0	11	0	1,820.00

Class H, designed to handle very heavy and rough materials. Flat link side chains are used, and the closing power is materially increased.

TABLE 63

Capacity, Cu. Yds.	Weight Lbs.	Dimensions, Open — Width, Ft.	In.	Length, Ft.	In.	Price
1½	4,000	3	9	8	6	$ 715.00
2	5,200	5	0	8	6	975.00
3	6,700	6	0	9	9	1,365.00
5	11,500	7	0	11	0	1,950.00

Scraper Clam Shell Buckets, for handling ore and extra hard, heavy material.

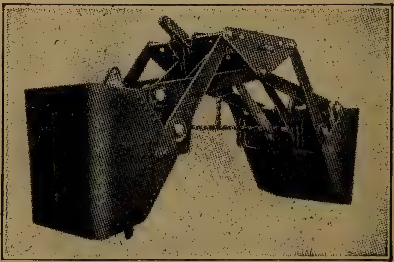


Fig. 40. Scraper Clam Shell Bucket

TABLE 64

Capacity, Cu. Yds.	Weight Lbs.	Dimensions, Open — Width, Ft.	In.	Length, Ft.	In.	Price
1½	4,500	3	6	12	0	$ 617.50
2	6,000	4	0	12	0	780.00
3	8,000	5	0	14	6	1,105.00
5	12,500	5	6	16	0	1,820.00
10	20,000	8	0	16	0	2,600.00

ORANGE PEEL BUCKETS

Standard orange peel buckets are adapted to all classes of dredging and excavating. They are good all around digging buckets, and are sometimes used for handling ore.

TABLE 65

Capacity	Weight Lbs.	Diameter Closed, Ft.	Diameter Closed, In.	Diameter Open, Ft.	Diameter Open, In.	Price
1 cu. ft.	125	1	9	2	2	$ 113.75
5 cu. ft.	900	3	2	4	0	292.50
9 cu. ft.	1,100	3	10	4	8	325.00
15 cu. ft.	2,350	4	6	5	6	503.75
1 cu. yd.	4,200	5	8	6	10	682.50
1½ cu. yds.	5,250	6	4	7	8	1,040.00
2 cu. yds.	8,500	7	0	8	6	1,137.50
3 cu. yds.	10,000	8	0	9	10	1,397.50

Extra heavy standard orange peel buckets are adapted for digging harder materials. Cast steel points, placed outside where sticky material is to be handled, are furnished.

TABLE 66

Capacity	Weight Lbs.	Diameter Closed, Ft.	Diameter Closed, In.	Diameter Open, Ft.	Diameter Open, In.	Price
21 cu. ft.	4,100	5	0	6	4	$ 682.50
1 cu. yd.	4,600	5	8	6	10	747.50
1½ cu. yds.	8,500	6	4	8	0	1,137.50
2 cu. yds.	9,500	7	0	8	6	1,267.50
3 cu. yds.	11,500	8	0	9	10	1,527.50
5 cu. yds.	20,000	9	6	11	4	2,502.50
10 cu. yds.	30,000	12	0	14	6	4,030.00

Multi-power orange peel buckets are used for digging clay, compact sand, and other hard material, and are built about as the extra heavy standard, but differ in the closing mechanism, which in this case has twice the closing and half the lifting power.

TABLE 67

Capacity	Weight Lbs.	Diameter Closed, Ft.	Diameter Closed, In.	Diameter Open, Ft.	Diameter Open, In.	Price
21 cu. ft.	4,200	5	0	6	4	$ 747.50
1 cu. yd.	4,750	5	8	6	10	812.50
1½ cu. yds.	8,500	6	4	8	0	1,300.00
2 cu. yds.	9,500	7	0	8	6	1,430.00
2½ cu. yds.	10,500	7	8	9	4	1,560.00

Three-sided orange peel buckets are especially well adapted for the handling of boulders, broken rock, and other odd-shaped materials difficult to hold unless an even force is exerted on bearing part. This is possible with this three-bladed bucket.

An excellent illustration is given in Fig. 41 of what a three-bladed orange peel bucket can do. The points of three-bladed buckets coming in contact with a boulder or pile will either force it inside the bowl or will grasp the object as in the illustration in such a manner that the holding force will be positive and the strain equally divided.

Fig. 41. Three Bladed Orange Peel Bucket.

TABLE 68

Capacity	Weight Lbs.	Diameter Closed, Ft.	Diameter Closed, In.	Diameter Open, Ft.	Diameter Open, In.	Price
21 cu. ft.	4,200	5	0	6	4	$ 715.00
1 cu. yd.	4,750	5	8	6	10	812.50
1½ cu. yds.	8,500	6	4	8	0	1,202.50
2½ cu. yds.	10,500	7	8	9	4	1,300.00

BUILDINGS

The only buildings that properly need be described in a book of this character are those of a temporary or semi-permanent character.

Mr. H. G. Tyrrell says, "Roughly speaking, the cost of one-story building, complete, is, for sheds and storage-houses, 40 cents to 60 cents per square foot of ground, and for such buildings as machine-shops, foundries, and electric-light plants that are provided with traveling cranes, the cost is from 60 cents to 90 cents per square foot of ground covered."

Kidder's Architects' and Builders' Pocket-Book gives the cost of a large car barn of exposed iron construction and brick walls erected in 1895 as 9 cents per cubic foot.

Mr. Fred T. Hodgson, in the Architects' and Builders' Magazine, gives the following:

Second class stable with common fittings—per cu. ft., 11 cents to 13 cents; per sq. ft., $1.65 to $2; per cow, $130 to $140.

Third class stable for farms, wood fittings—per cu. ft., 7½ cents to 10 cents; per sq. ft., $1.45 to $1.50; per cow, $90 to $105.

The following has been compiled by James N. Brown: Barns, framed, shingle roof, not painted, plain finish, 1½ cents to 2½ cents per cu. ft.

Barns, framed, painted, with good foundation, 2½ cents to 3 cents per cu. ft.

The following is from H. P. Gillette's Handbook of Cost Data:

COST OF ITEMS OF BUILDINGS BY PERCENTAGES

	Brick Warehouses Per Cent	Machine Shop (150x400) Per Cent
Excavation, brick and cut stone	50	15
Skylights and glass	..	10
Millwork and glass	7	6
Lumber	18½	6½
Carpenter labor	9½	4
Tin, galv. iron and slate	..	1½
Gravel roofing	2	1½
Structural steel	..	45½
Steel lintels and hardware	8½	6
Plumbing and gas fitting	2	..
Piping for steam, water and power	..	2
Paint	2½	2

The labor cost of framing and erecting plain framed buildings averages from $10 to $15 for one thousand feet B. M.

The cost of section houses, with three rooms, of cheap construction averages 54 cents per sq. ft.

Cost of six tool houses, 8′x12′, area 96 square feet:

Item	Cost per Square Foot	Total Cost
Materials	.161	$15.53
Labor	.134	12.90
Tools	.005	.48
	.300	$28.91

The lumber and labor in the above were very cheap.

Cost of a blacksmith shop, 20'x30', area 600 square feet, no floor, no studs in the sides, most of material second hand:

2,120 ft. B. M., @ $4.60	$ 9.76
4½ M shingles, @ $1.65	7.43
Hardware	.77
Total materials	$17.96
Superintendence	$ 4.80
Carpenter, @ $2.10	21.82
Total labor	$26.62
Cost per square foot	$.072

In contrast with the above cost, note the cost of an extremely well built, portable blacksmith shop, built in New York City in 1910, 18'x30'x11' high, fitted with shelves, closet and racks:

Lumber, @ $30 M.B.M—5 window frames and sash, 2 large doors framed at mill, rubberoid roofing	$140.00
Hardware	15.00
Painting and paint (contract)	15.00
Labor—carpenters, @ $4.50; common labor, @ $1.50 per 8 hours	130.00
Total	$300.00
Cost per square foot	$0.55

Portable offices and houses ready to be fitted together and with one coat of paint can be purchased in almost any of the large cities. Below are prices on portable houses, manufactured in New York:

	Feet		Per Sq. Ft.
Inspector's office	8x9	$ 55.00	$0.76
Tool house	6x8	30.00	.62
Office and tool house	10x12	90.00	.75
	10x16	110.00	.69
	10x20	135.00	.68
	8x12	65.00	.67
	8x16	80.00	.62
	8x20	100.00	.63
Peak roof house	12x24	185.00	.64

All of white pine partitions, tongued and grooved, and center beaded, bolted, windows netted.

In *Engineering and Contracting*, Oct. 7, 1908, the cost of camp buildings used on a concrete dam contract in a small town 200 miles from Chicago is given.

The camp consisted of the following buildings:

Building	Floor Area, Sq. Ft.
8 dormitories for 283 men	15,000
2 mess halls for 80 men	3,000
3 individual shacks for 3 men	864
1 storehouse	1,136
1 machine shop	900
1 blacksmith shop	100
Total floor area	21,000

The cost of constructing these buildings was as follows:

Item	Cost
158,000 ft. B. M. of lumber at $22.50	$3,575
15 carpenters 48 days at $3	2,160
30,000 sq. ft. tar paper at $0.0225	675
Nails	145
Total	$6,555
Interest and depreciation	$5,500

The cost per square foot of building was as follows:

	Per Sq. Ft.	Per Cent
Lumber	$0.17	55
Labor	0.10	32
Roofing and hardware	0.04	13
Total	$0.31	100

The carpenter work cost $13.70 per 1,000 ft., B. M.

CABLEWAYS

The following data are taken from Gillette's "Rock Excavation": Nineteen cableways with spans of from 550 to 725 ft. were used on the Chicago Drainage Canal. The main cableways were 2¼ ins. in diameter with a sag of 5 ft. in 100 ft., supported on towers from 73 to 93 ft. high. The haul and hoisting cables were ¾ in. in diameter and the button and dumping cables ⅝ in. in diameter. The life of the main cable was from 50,000 to 80,000 cubic yards of solid rock, or 30,000 to 50,000 trips, or 100 to 160 days. A 70 H. P. boiler and a 10x12 engine operated the skips with a speed of 250 ft. and a traveling speed of 1,000 ft. per minute. The skips were 2x7x7 ft. of steel, weighing 2,300 lbs., and holding 1.9 cubic yards of solid rock. Total weight of the cables, cars, skips and all was about 450,000 lbs. and cost $14,000.

The force consisted of a foreman at $3.00, an engine man at $2.75 per 10 hours; a fireman at $1.80, a signalman and a towerman at $2.70 each, and laborers at $1.50 each, loading skips. The output ranged from 300 to 450 cubic yards of solid rock per 10 hrs., loaded and handled at a cost of 28 to 30 cts. per cubic yard. This does not include rental of plant.

The following table gives the cost in percentages:

TABLE 69

	Labor (2/3)	Supplies (1/3)	Total (3/3)	Assuming 50 Cts. per Cu. Yd., Cost per Cu. Yd. in Cts.
Drilling	22	10	18	9.0
Explosives	3	58	21	10.5
Loading	46	2	31	15.5
Conveying	15	20	17	8.0
Channeling	4	3	4	2.0
Pumping	4	7	5	2.5
Supt. and genl. labor	6	..	4	2.0
Total	100	100	100	50.0

On section 7 nine skips and about 35 men worked on a face. About 1½ tons of coal and 25 cts. worth of oil were consumed each shift.

The cost of earth excavation for a cableway of 400 ft. span is given in Gillette's "Earthwork and Its Cost." The earth was delivered to a chute and thence to cars. The cost, which did not include the timber sheeting, the hauling or unloading of cars, was 30 cts. per cubic yard. To move one of these cableways takes a gang of 15 men three days, if green; two days if accustomed to the work, and costs from $50 to $75. If this cost is added to the cost of excavating the earth in a trench 375 ft. long it will amount to several cents per cubic yard. If the trench is 6 ft. wide and 9 ft. deep the charge will be about 10 cts. per cubic yard.

In building a bridge across the Delaware river on the D. L. & W. R. R. most of the concrete and other materials were handled by a cableway. This was a double-span duplex cableway with a span of 2,005 ft., which was divided near the center by an A-frame. The cables were 14 ft. apart, the two towers were about 130 ft. high, while the A-frame was 75 ft. high. The main cables were 2¼ ins. in diameter and the operating ropes ¾ in. About 5,000 ft. of main cable and 10,000 ft. of line were used. Each span was operated by a 125 H. P. locomotive boiler with a 50 H. P., 10x12 in. double cylinder, double friction drum, reversible link motion cableway engine; drums 54 ins. in diameter, 48 ins. long between flanges. The load operated by each engine was 5 tons, making 15 to 20 trips per hour. Four engineers, two firemen and one rigger were necessary to operate the cableway. The entire plant cost about $22,500, erected.

A Duplex Traveling Cableway was used by the United States government in excavating the Hennepin Canal. The cableway was purchased in 1903 and cost, complete and in operation, $28,580. It consisted of 2 complete and independent cableway systems mounted on a single pair of duplex traveling towers. One tower served as a head tower for one cableway, the other tower served as a head tower for the other cableway. These towers were

Fig. 42. Duplex Cableways Used on Hennepin Canal, Operating Two 1½ Cubic Yard Orange Peel Buckets.

built of heavy timber well braced and ballasted. Each contained about 40,000 ft. B. M. of timber and 4,000 lbs. of iron work. They were mounted on 47x54 ft. platforms supported by 48 standard car wheels set in two parallel frames 54 ft. long, and moved on 5 lines of rails laid parallel to the axis of the canal. These rails were so laid as to form two standard gauge tracks with centers 29 ft. apart, and one single rail between them. Each tower was equipped with a special 12¼x15 in. double

cylinder cableway engine with 3 tandem 51 in. friction drums and a 125 H. P. locomotive fire box boiler. The cableways were 18 ft. apart and had a span of 625 ft. Each was equipped with a 1½ cubic yard orange peel bucket operated at the same time and independently. From October 10th to December 20th a total of 131,414 cubic yards were excavated. The total operating expense for this period was $11,546, divided as follows:

Labor, $7,261; repairs, renewals, lubricating oil, kerosene oil for lights, waste, etc., $3,528; coal $757. The operating cost per cubic yard was 8.8 cts. The item for repairs, renewals, etc., includes $1,350 worth of new cables, but it is stated only about one-third of this sum could justly be charged to the operating cost of this period. During the period of operation for which the cost data are given the towers were moving over very soft ground. This made the track work expensive and was the cause of a number of extraordinary breakages; for instance, 3 crank shafts on the engines were broken.

A cableway used as a framework for a track carrying cars for making a fill was erected near Cleveland, Ohio. The fill was across a gorge 400 ft. wide and 95 ft. deep. One small trestle bent on each bank and one tall bent in the center were erected. Two 2¼-in. galvanized cables 7 ft. apart, were stretched over the bents and anchored to dead men of buried logs. The rails were spiked to ties which were fastened to the cables by U bolts. Small trestle bents were put in as the fill advanced. Turn buckles were placed in the cable to keep the suspended track taut.

Actual cost of aerial cable roadway:

2¼ in. galvanized bridge cable, 1,000 ft.	$ 600.00
Eyebolts, 2½ ins. diam., with clevises for both ends	108.30
Turnbuckles at north end 3-in. diam.—two	120.00
Chains at north end, 2½ in. iron—two	62.40
Cast washers, 8 ins. diam., 2 ins. thick—four	2.46
Timber for A-frame (all other timber was obtained on ground): Upper 42 ft., 14 ft. x 8 ins. x 8 ins. All bracing and cross ties; 3,800 ft., at $34 per M	108.80
Lower 50 ft., round timber, 56 ft. long: Rough in tree	32.00
Cost of team work for hauling round timber, and pulling timber to place for erecting	65.00
Carpenter labor on A-frame and end bents on bank	231.40
Time of superintendent, getting material and overseeing work in general	60.00
Common labor: Digging trenches for anchors and putting up cableway	112.00
Nails and iron in A-frame and bents	29.40
Total cost of cableway	$1,531.76

Estimated cost of timber trestle:

Timber (all uprights, planks for bracing, stringers, etc.), 98,000 ft., at $26 per M	$2,548.00
Labor, at $6 per M	588.00
Spikes	98.00
Iron drift bolts	40.00
Total	$3,274.00
Balance in favor of cableway	**$1,742.24**

The following is abstracted from Gillette's "Handbook of Cost Data."

Cost of Cordwood and Cost of a Wire Rope Tramway. Mr. B. McIntire gives the following about a wire ropeway built by him in 1884 in Mexico. He states that when the inclination of an endless traveling ropeway is greater than about 1 in 7 it will run by gravity, the speed being controlled by a brake. A ropeway running 200 ft. per min. with buckets at intervals of 48 ft., each carrying 160 lbs., will deliver 20 tons per hour. By using two clips close together on the rope, loads of 700 lbs. per bucket may be carried. This particular ropeway was used for carrying cordwood to a mine. Its total length was 10,115 ft. between terminals, and the difference in elevation was 3,575 ft. The longest span between towers was 1,935 ft.; the shortest, 104 ft. There were 10 towers and two terminals. Hewed timbers were used for the towers, being much better than round timbers in maintenance. The rope was $\frac{13}{16}$-in. diam., plow steel of 300,000 lbs. strength per sq. in. It was transported on 7 mules in lengths of 2,250 ft., each mule carrying a coil 321 ft. long, with a piece 10 ft. long between mules. The coils were 24 ins. in diam. There were 3 men required to every 7 mules. Care must be taken to lead the mules on a steep ascent to prevent a sudden rush that may throw a mule over a precipice. The ropeway, after erection, was lubricated best by using black West Virginia oil (instead of tar), applied continuously at the rate of a drop a minute. This was vastly better than intermittent oiling.

The cost of this ropeway was as follows:

Upper terminal	$ 192.45
Lower terminal	218.00
5 trees fitted for towers	103.00
5 towers	854.25
Counterweight tower	169.00
Remodeling towers	332.00
Stretching, splicing and mounting rope, attaching clips and baskets	255.00
Total labor cost of construction	$ 2,123.70
Opening and maintaining roads	1,822.30
Ropeway, materials and transportation	15,454.00
Total cost in running order	$19,400.00

This is equivalent to about $10,000 a mile. During 9 months the ropeway was operated at a cost of $400 a month, and handled 660 cords per month; the items of cost being as follows for 9 months:

1 brakeman, at $52 per month	$ 468
3 men filling, at $26 per month each	702
1 man dumping, at $40 per month	360
1 man looking after line and oiling, at $26	234
Oil	117
Repairing (very heavy, $2.25 per day)	526
2 men wheeling wood away from terminal	468
2 men receiving wood from choppers and delivering it to packers	702
Total for 9 months	$3,577

It will be noted that the cost of labor was low, being $1 a day for common labor. The cost of cutting and delivering wood to the tramway was $2.20 per cord, and the cost of transporting by the tramway, as above given, was 60 cts. per cord (not including interest on the plant). During the previous year the cost of cutting and teaming wood had been $12 per cord. The total saving to the company, after deducting cost of tramway, was $33,500 the first year.

An Aerial Cableway 4.8 miles long has been used for conveying contractors equipment, materials and supplies for the construction of the reservoir dam of a new hydro-electric plant at Loch

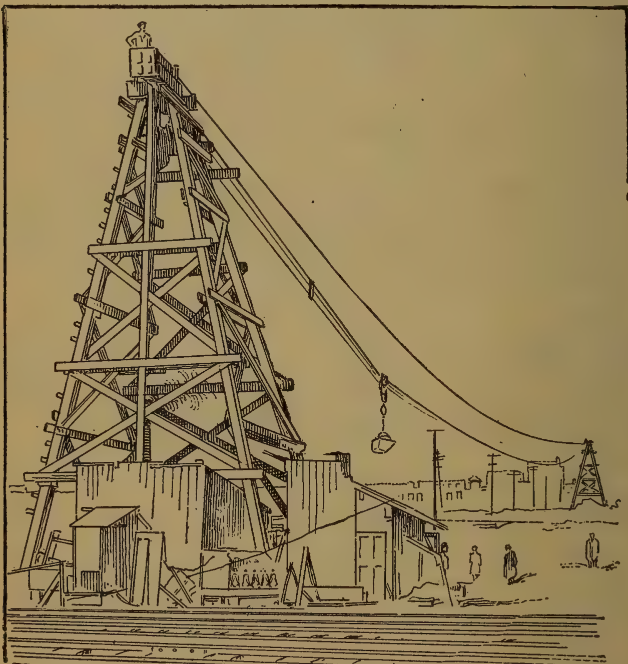


Fig. 43. 10-Ton Cableway; 800-ft. span with 50-ft. Four-Post Towers.

Leven, Scotland. The ground between the loch and the dam, which is at an elevation of 1,075 ft. above the loch level, is very steep, rendering transportation by any method other than a cableway almost impossible. The mean gradient is 1 in 22.8 against

the loads. There are six stations for loading and unloading, three being at the angles in the line. The single rope system is used, being supported by 86 wooden towers of an average height of 24 ft. The longest span is about 900 ft. The power driving the ropeway is a Pelton wheel of 250 B. H. P., the speed being reduced by gearing so as to drive the rope at 300 ft. per minute. About 580 buckets, with a capacity of 600 lbs., are used, and spaced about 90 ft. apart. The material handled varies from 700 to 1,000 tons per day. Twenty men are engaged in its operation; one man at the power house, three men at each of the three angle and delivery stations, four men at the upper and four at the lower terminal for handling the materials and the buckets, and two men for lubricating the pulleys on the towers. The upper terminal is a trestle 105 ft. long, 20 ft. wide, and 50 ft. high, containing bins for storing 450 to 500 tons of ballast. The total cost of the line, according to *The Engineer*, London, from which these notes are taken, was $62,500, or at the rate of about $12,500 per mile. The estimated cost of operation per ton-mile, allowing for redemption in three years, labor, and 10 per cent on the labor account for supervision, is 4 cents.

Handling Concrete. Cableways can be used advantageously for handling concrete. A cableway with a span of 800 ft., and stationary towers 45 ft. high, capable of handling a bucket containing a yard of concrete, costs from $4,500 to $5,000. Movable towers cost about $1,000 more.

Cost of Rock Removal. On the St. Mary's Channel improvement, West Nubick Channel, four cableways were used to excavate 1,600,000 cubic yards of rock. This was accomplished in 2½ years. After blasting, the rock was loaded into skips by steam shovels and the skips were hoisted and conveyed by cableway. Average haul, 300 ft. The rock cut varied from 27 ft. to 0 ft., average being 15 ft. Skips 8 ft.x30 in. In June, 1907, 76,752 yds. were excavated, or an average of 3,073 cu. yds. per day; in August the output was 88,000 yds.; average yardage from May to August, four months, was 85,000 yds. per month. One cableway made a monthly record of 29,490 yds.

The cost of an average cableway without towers to carry a 5-ton load 800 ft. span with deflection at center of about 5% of the span, complete with guys but without towers, 12x12 engine working at 90 lbs. to 100 lbs. pressure, steam or air, with dumping drum without boiler is between $6,000 and $7,000 f. o. b. the manufacturer's works. The cableways operating by electricity, including 150 H. P. motor with controllers and resistances cost about $1,500 more than the above, or just about enough more to offset the cost of the boiler plant if a separate boiler has to be installed for the cableway.

Cost of Towers. One A-frame tower, guyed, for each end of this type of cableway will require a minimum of 5,000 ft. B. M. of lumber, with 14 in. x14 in. sticks, costing about as follows:

Timber, Y. P., 5,000 ft., B. M., at $50	$250.00
Labor erecting, about	125.00
Fastenings, freight and haulage, say	100.00
Total for 1 tower in place	$475.00

This tower can be taken down and reset for about $50 plus the cost of moving to the new location. I do not know of towers of this type being built higher than 80 ft. and would advise against anyone attempting to construct A-frame towers higher than 65 ft. unless they have had much previous experience of the use of such very long sticks. The above figures are approximate, of course, and apply to average conditions in New York State. A 4-leg tower takes about three times as much lumber as an A-frame tower.

Traveling towers for a cableway cost from three to five times that of fixed towers under the same general conditions.

Repairs on a cableway may be counted at ½-ct. per cu. yd. of material handled.

Three cableways on the D. J. McNichols portion of Philadelphia Filtration System, Torresdale Filters, carried concrete, which was handled in dumping tubs. Each cableway averaged 200 buckets per day of 10 hours, and a record of 330 buckets or 495 yard rods was made by a single cableway in one day. One of these cableways with a span of 825 ft. cost $4,200 without towers. The towers were 64 ft. high. After being used three years this plant was sold for $3,500.

A cableway for Baker Contract Co., at U. S. Lock and Dam No. 4, Ohio River, with a span of 1,485 ft. designed for a load of 5 tons, with 2¼-in. cable between 103 ft. towers, cost $6,500, exclusive of boiler and towers.

Cost of Erection and Plant. The Croton Falls Const. Co., at the Croton Falls Dam, put in two cableways 1,434 ft. long, 2¼-in. cables, carrying 5 to 10-ton loads. The cost of one of these was $8,000, exclusive of towers, tracks and boilers. The engine and boiler for this plant cost $3,300, or 41.3% of the cost of the plant.

A report made by the Construction Service Co. shows the labor cost of erecting four towers and stringing cables for the two cableways as follows:

Average height of towers: Head, 73 ft. Tail, 103½ ft.

Carpenter foremen	49.25	@ $6.00	=	$ 295.50
Carpenters	312.25	@ 3.50	=	1,093.38
Hoisting engineer	104	@ 3.00	=	312.00
Fireman	57.5	@ 2.50	=	143.75
Laborers	330.5	@ 1.60	=	528.80
Teams (labor only)	47	@ 1.50	=	70.50
Foreman riggers	45	@ 6.00	=	270.00
Rigger helpers	374	@ 2.50	=	1,135.00
Machinist	4	@ 6.50	=	26.00
Machinist helper	16	@ 3.00	=	48.00
Foreman (laborers)	15.5	@ 2.00	=	31.00
Cableway engineer	19	@ 4.25	=	80.75
Signalman	23	@ 1.50	=	34.50
Cableman	18	@ 3.00	=	54.00
				$4,123.18

Work Accomplished. On North Channel, St. Lawrence River, two cableways costing $7,000, exclusive of towers and tracks, excavated over 500,000 tons of heavy stratified limestone. 75% of this was handled in blocks of 3 to 15 tons and 25% in 4-yd. skips, 20,000 to 25,000 cu. yds. handled per month the year around 1,000 tons per day was averaged. Delays on one cableway in 11 months due to repairs were 19 hours and 49 minutes.

Moving Cableways. In the construction of the Southern Outfall Sewer, Louisville, Ky., two 700-ft. double Lidgerwood cableways were moved several times. Each time the cableway was dismantled and two traveling cranes assisted in the moving. The towers were 60 ft. high. About 20 men were employed in moving, and the cost of moving and setting up each time was between $380 and $400.

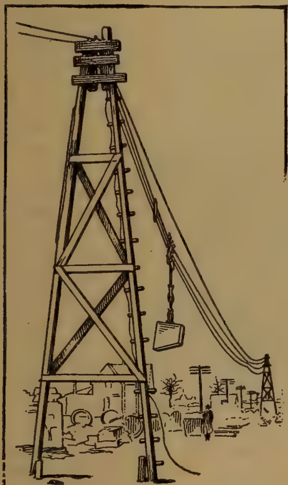


Fig. 44. Sewer Cableway.

Output. On the Holyoke Water Power Dam a cableway with a cable 2 ins. in diameter, supported by a frame tower 20 ft. high on one side and a similar tower 100 ft. high on the other, set with a difference in elevation of the tops of 40 ft., was used for conveying materials. Most of the travel was down grade. The total span was 1,615 ft., total distance between anchorages 2,200 ft. A fifty H. P. engine with two drums was used for hoisting. The average round trip to the center of the span with 3 cu. yds. took ten minutes. This is at the rate of 18 yds. per hour or 180 yds. per day.

Life. In constructing the Rocky River Bridge at Cleveland, Ohio, a cableway with a 800-ft. span was used. This was mounted on towers which ran on rollers so that the whole machine could be shifted sideways. It was capable of carrying 10 tons. The main cable was 3 inches and the load line ¾ of an inch in diameter. Once every three months the main cable was shortened to take out the sag. The line had a life of eighty to ninety days and after being removed was used on small derricks, etc.

The Lidgerwood High Speed Cableway. With long spans, the time required to move the carriage along the cable at speeds up to 600 or 800 ft. per minute made horizontal transportation a large item in the cost of handling materials in this manner, but with the ordinary type of apparatus higher traveling speeds were not practicable. The fall rope carriers were damaged and the "buttons" could not be made to retain their

position on the cable. The effect of impact being somewhat proportional to the square of the speed of the moving load, the necessity for radical changes in equipment that would meet an increase in running speed of two hundred per cent is apparent. For this purpose Mr. Spencer Miller has developed a new type of "button" and a special shock absorbing fall rope carrier, both of which are extremely ingenious and effective. Electric cableways so equipped have operated on the Panama Canal work. These cableways operated at a running speed of 1,800 to 2,000 ft. per minute, driven by General Electric, inter-pole, series wound railway type motors of 150 h. p., wound for 550 volt D. C. circuit. These motors were equipped with a current limit automatic and hand control, whereby the operator may cause the motors to be accelerated by throwing the master-controller handle to full-on position, the motors taking a pre-determined current from the line. The motors may be slowed up by a retrograde movement of the controller handle, thus cutting resistance back into the motor circuit. The control panel carries an overload relay which throws the motor off the line in case of overload by causing the line contactors to drop out. Before the motor can again be thrown on the line it is necessary for the operator to bring the master-controller handle to the off position, after which the motors are started in the usual manner. The brakes are electrically-operated air brakes, as well as friction clutches, a separate electrically-driven air compressor being employed. The control arrangement both for the air brakes and friction clutches is designed for operation locally or at a remote point.

These cableways, in a battery of eight (4 duplex), have placed about 2,900 cu. yds. of concrete in one day of 12 hours, in addition to handling forms and iron work for the day's work.

The hoist has cast steel gearing with machine-cut teeth throughout. The diameter of the hoisting and conveying drums is 54 inches and the hoist is geared to give a hoisting load speed of 333 feet per minute.

The duplex cableway towers travel the whole length of the flight of locks, about 3,000 feet. There are eight cableways in the set, arranged on four pairs of traveling duplex towers. All the towers are readily moved along the tracks by special electric winches. The towers are provided with brake apparatus and locking clamps, in addition to the solenoid brakes on the propelling winches. This is necessary on account of the grade of trackway, which is 2.1 per cent for a large part of its length.

CARS

Double side or double end all steel dump cars cost as follows:

TABLE 70

Capacity Cu. Ft.	Gauge of Track Ins.	Overall Dimensions Length	Width	Height	Weight, Lbs.	Price
18	20	5′ 7″	4′ 3″	3′ 4″	700	$52.00
27	20	5′11″	4′10″	3′11″	850	58.00
18	24	5′ 7″	4′ 3″	3′ 8″	750	55.00
27	24	6′ 2″	4′10″	4′ 0″	875	58.00
36	24	6′ 9″	4′11″	4′ 3″	975	68.00
36	30	6′ 9″	4′11″	4′ 5″	1,050	70.00

Hand operated brakes, $20 per car extra.
Brake cars are about 15 in. longer.

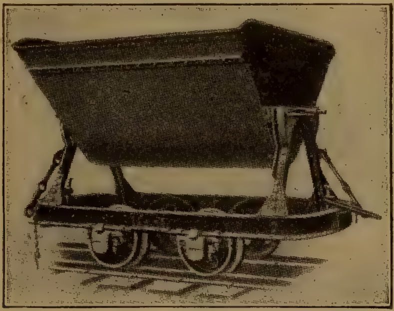


Fig. 45.

Rocker, double side all steel dump cars cost as follows:

TABLE 71

Capacity Cu. Ft.	Gauge of Track Ins.	Overall Dimensions Length	Width	Height	Weight, Lbs.	Price
18	24	6′9″	4′ 0″	3′ 8″	900	$54.00
27	24	7′4″	4′ 2″	3′11″	950	58.00
40	24	8′1″	4′11″	4′ 5″	1,325	70.00
27	30	7′7″	4′ 2″	3′11″	1,000	60.00
40	30	8′1″	4′11″	4′ 7″	1,425	78.00
54	30	8′8″	5′ 3″	4′10″	1,675	90.00
40	36	8′1″	4′11″	4′ 8″	1,500	80.00
54	36	8′8″	5′ 3″	4′11″	1,770	92.00

Hand operated brakes $20 per car extra.

Unloading thirty 30-in. gauge 36 cubic feet capacity cars, similar to above, from flat cars and hauling about one mile, cost $39.50, or about $1.32 per car. Foremen, 35 cts.; teams and drivers, 50 cts., and laborers, 15 cts. per hour.

In excavating a bank of hardpan with a 14-ft. face in 1907, the following equipment and men were used:

10 steel double side dump cars, 36 cubic feet capacity, 36-in. gauge at $72.50	$ 725.00
2 brake cars at $92.50	185.00
2 switches complete at $30.00	60.00
1,500 ft. of 30-lb. rail and plates, etc. = 600 ft. of track and 1 turn-out at 19 cts. per ft.	285.00
200 ties, 6"x4" spruce, 5½ ft. long	49.50
Spikes and bolts	40.00
Total cost of plant	$1,344.50

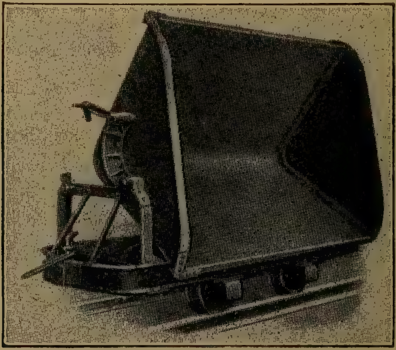


Fig. 46.

1 foreman at $3.00	$3.00
6 pick and bar men at $1.50	9.00
12 shovelers at $1.50	18.00
1 horse and driver at $3.50	3.50
½ trackman at $1.50	.75
1½ dumpmen at $1.50	2.25
Total labor cost per 10 hours	$36.50

The earth, which was extremely hard, was undermined and pried down with picks and bars, and loaded into a train of six

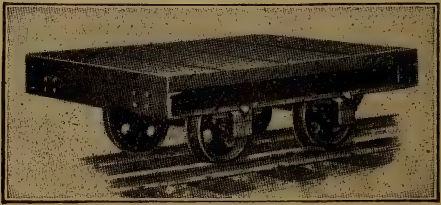


Fig. 47.

cars. The whole gang then started the train, which ran down the 4% grade to the dump by gravity. After being dumped, it

was hauled back by one horse. Thirty-three trains or 198 cars, well loaded, per day, was the output. A car was found to contain about 1 cubic yard of earth place measure. This gives a labor cost of about 18.5 cents per cubic yard. About $1.75 per day was spent on repairs to the equipment.

On another job two trains of ten cars each were used. The gang was as follows:

1	foreman	@ $3.50	$ 3.50
20	loaders	@ 1.50	30.00
1	dump foreman	@ 1.60	1.60
3	dump men	@ 1.50	4.50
2	brakemen	@ 1.60	3.20
1	trackman	@ 1.60	1.60
2	pickmen	@ 1.50	3.00
1	waterboy	@ 1.00	1.00
2	extra men	@ 1.50	3.00
1	hauling team and driver	@ 5.00	5.00
1	plow team and driver	@ 5.00	5.00
	Total		$61.40

The earth was of hardpan and sand and the cut ranged from 0 to 15 feet. The fill was about 9 feet in height. The average haul was 800 feet. Thirteen hundred feet of track was laid at

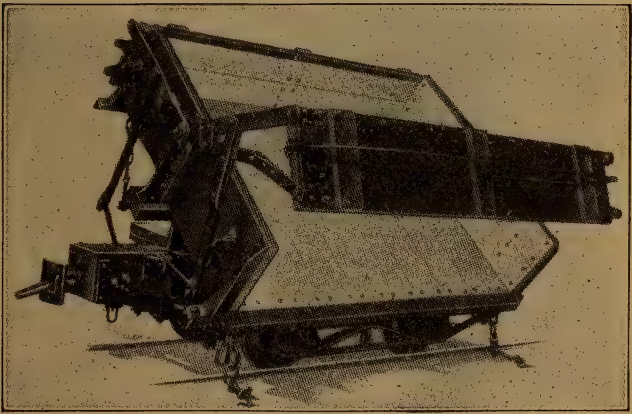


Fig 48. The Oliver 4-Yard Car.

a cost of $75. The average daily output was 330 cars, or yards, making a labor cost of about 19 cents per yard.

Cars similar to these were loaded by a 30-ton traction shovel for 10 cents (contract) per yard, and dumped and hauled back by horses for 7 cents per yard, average length of haul 1,500 feet.

The repairs on cars were very high, amounting to about 4 cents per yard, but had stronger cars of the same type been used, the repairs would have been nominal.

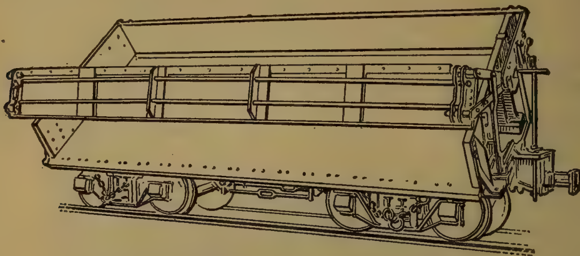


Fig. 49. 8-Yard Car in Dumped Position.

A diamond frame double side dump car of wood and steel, costs as follows: Fig. 50.

TABLE 72

Capacity, Yds.	Weight, Lbs.	Equipment	Price
4	6,000	Link and pin coupling and air brake	$195.00
6	11,000	Automatic coupler, hand brake	275.00
6	11,000	Automatic coupler, air brake	325.00
12	28,000	Double trucks, automatic coupler and air brake	750.00

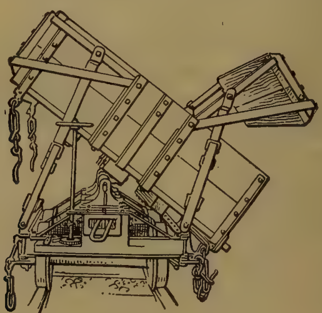


Fig. 50.

A two-way dump car, diamond frame, of white oak, strongly reinforced with steel, costs as follows:

Listed Capacity, Yds.	Weight	Trucks	Gauge	Brake	Price
4	5,988	Single	36″	Hand	$165.00
6	10,875	Single	36″	Hand and Air	255.00
8	16,500	Double	36″	Hand and Air	435.00
12	28,000	Double	Standard	Hand and Air	750.00

The manufacturers present the following figures:
Capacity of 4-yard car....... 3.9 cu. yds—of 2 cars 7.8 cu. yds.
Capacity of 8-yard car....... 9.8 cu. yds.
Length of 4-yard car over all 13'6—of 2 cars 27'
Length of 8-yard car over all 22'6"

A train of twelve 4-yard cars hauls 46.8 cubic yards of earth.

A train of six 8-yard cars hauls 58.8 cubic yards of earth; a gain of 25 per cent.

A train of twelve 4-yard cars is 182 feet in length.

A train of six 8-yard cars is 135 feet in length.

Length saved in "spotting" by using 8-yard cars, 47 feet; a gain of 2 per cent per train foot, and a 50 per cent saving in time dumping. The increased diameter of wheels under an 8-yard double-truck car enables a dinky to handle more yardage than with 4-yard cars.

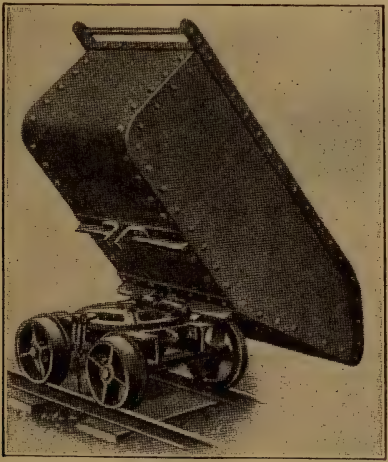


Fig. 51.

Revolving dump cars similar to Fig. 51 cost as follows:

TABLE 73

Capacity, Cu. Ft.	Track Gauge, Ins.	Weight, Lbs.	Price
18	18, 20 or 24	540 to 550	$45
18	30	560	50
27	18, 20 or 24	740 to 750	52
27	30	760	55

Flat cars with 4 wheels, having frames and platforms of wood, steel axles, and cast iron wheels, cost as follows:

TABLE 74

Capacity, Tons	Gauge, Ins.	Platform Width	Platform Length	Weight, Lbs.	Price
2	36	50	72	750	$ 26.00
5	42	57	84	1,100	34.00
10	56½	76	96	1,200	56.00
15	56½	81	108	1,300	100.00
20	56½	84	120	1,400	170.00

Double-truck platform cars with wooden frames and trucks with wooden or steel bolsters (Fig. 52) have the following capacities:

TABLE 75

Capacity, Tons	Track Gauge	Platforms Length	Platforms Width	Weight, Lbs.	Price
8	30", 36", 42", 39.37"	20′	6′	6,000	$220.00
10		26′	6′	9,500	300.00
12		30′	6′	11,500	330.00
15		30′	8′	13,000	400.00
20		32′	8′	18,000	475.00
25		34′	8′6"	22,000	520.00
30	4′8½"	36′	8′6"	24,000	620.00

These cars are regularly equipped with hand brakes working on one truck only, and link and pin couplers. For brakes working

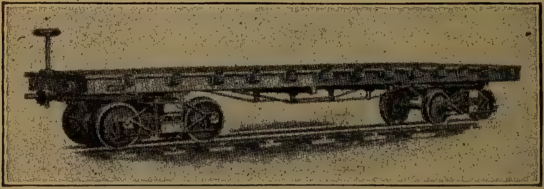


Fig. 52.

on both trucks add $12 to $15. For automatic couplers add $14 to $20. For air brakes add $50 to $60.

Cars similar to above with steel frames and trucks cost 25 per cent more.

Inspection and hand cars operated by foot or hand are of three general types: foot driven, velocipede type, 4 wheels, weight 70

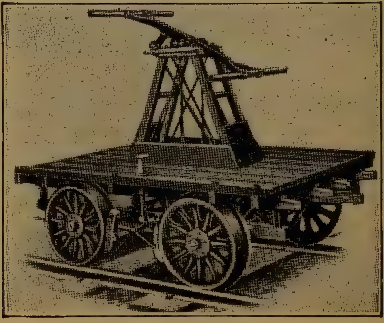


Fig. 53.

lbs., price $70; hand driven, 3 wheels, weight 140 lbs., price $40; hand driven (Fig. 53), 4 wheels, weight 500 lbs., $40.

Platform Cars with steel frames similar to Fig. 47 cost as follows:

TABLE 76

Capacity, Tons	Track Gauge, Inches	Platform Length	Platform Width	Weight, Lbs.	Price
2 to 3	20	4′9″	3′0″	500	$28.00
2 to 3	24	5′0″	3′4″	550	29.00
2 to 3	24	6′0″	4′0″	640	32.00

Ordering. In ordering cars or making inquiries from manufacturers the following points should be noted.

Gauge of track.
Weight of rail on which cars run.
Radius and length of sharpest curve.
Style of car (give number of catalog cut nearest to your requirements).
Material to be handled and its weight per cubic foot.
Capacity of car in tons or cubic feet.
Give dimensions of car, if possible.
Any limitations as to height, length or width.
Style of coupling and drawbar.
Distance from top of rail to center of drawbar.
Method of operation—hand, animals, steam or electricity.
Whether to be used singly or in trains.
Number cars to a train.
Diameter of wheels and axles already in use, if new cars are to be used with old ones.
Style of axle boxes, if inside or outside, roller bearings, etc., if with or without springs.
Any other points to be considered.

Depreciation and Repairs. Ten new dump cars, some with steel and some with wooden bottoms, costing $50, drawn by horses, had a life of 4 years, and averaged $1.75 per car per month for repairs the first 18 months.

The following tables give the original cost and average repairs per month on about 22,000 cars on a large railroad system. I am indebted to Mr. J. Kruttschnitt for the data from which it has been compiled.

STEEL OR STEEL UNDERFRAME CARS

TABLE 77

Type of Car	Original Cost	No. of Cars	Monthly Average Repairs
Ballast	$ 889.81	460	$ 5.17
Box	1,085.00	2,304	1.57
Coal	674.65	1,594	3.47
Dump	1,461.63	300	4.37
Flat	845.00	2,289	1.05
Furniture	802.29	297	3.61
Gondola or ore	1,210.00	1,419	3.16
Oil	2,110.00	871	10.01
Stock	1,030.00	1,693	1.10

WOODEN CARS

TABLE 78

Type of Car	Original Cost	No. of Cars	Monthly Average Cost of Repairs
Ballast	$ 589.09	457	$ 4.78
Box	440.00	6,247	3.92
Coal	557.58	127	3.76
Flat	581.20	512	1.02
Furniture	530.00	278	7.44
Oil	1,800.00	247	13.05
Stock	450.00	2,700	3.61

The average cost of repairs on steel underframe cars was $2.79 and on wooden cars $4.04 per month.

Reports from various railroads indicate that the average cost of repairs of wooden cars varies from $35 to $85 per car per year, and of steel or steel underframe cars varies from $9 to $10 per car per year. The average life of a wooden car is about 15 years, and of steel cars about 25 years.

The cost of repairs on cars per year in percentage of the original cost is as follows:

Type	Steel Cars	Wood Cars
	%	%
Ballast	7.0	9.75
Box	1.7	10.7
Coal	6.2	8.1
Dump	3.6	..
Flat	1.5	2.1
Furniture	5.4	16.8
Gondola or ore	3.1	..
Oil	5.75	8.7
Stock	1.3	9.6

In the *Railroad Gazette*, October 11, 1907, Mr. William Mahl, comptroller of the Union Pacific and Southern Pacific railways, gives some valuable data as to the life of equipment on the Southern Pacific Railway.

The following are averages for the period of six years, 1902 to 1907, the costs being the average cost per year.

Class	No. Serviceable	Expenditure on each per annum Repairs	Vacated
Locomotives	1,540	$3,165	$183
Passenger cars	1,504	759	104
Freight cars	42,983	70	17

In "repairs" are included the annual expenditure for repairs and renewals of each locomotive or car, other than the expenditure for equipment "vacated." In "vacated" is included the cost of equipment destroyed, condemned and dismantled, sold or changed to another class.

From 1891 to 1907, a period of 17 years, the average number of freight cars "vacated" each year was 3.63 per cent of the total number in service. Dividing 100 by this 3.63, we get 27½, which is, therefore, the average life in years of each freight

car. These cars were nearly all wooden cars, of which the cost of a box car did not exceed $450, excluding air brakes.

The number of freight cars constantly in repair shops was 5 per cent of the total number for the three months ending March 31, according to Statistical Bulletin No. 4 of the American Railway Association. For the previous quarter the percentage was 5½ per cent. Each car averaged 23½ miles traveled per day. The above figures are based upon averages of almost 2,000,000 freight cars. In Group IV (Virginia, West Virginia, North and South Carolina) there were 124,000 cars, 7 per cent of which were in the repair shop at any one time. This group made the poorest showing of all.

On the Panama Canal work during the six months ending June 30, 1910, the cost per day of repairs to cars of all kinds was $1.03. For the same period the cost of repairs to plant and equipment per unit of work done was as follows:

Item	Cu. Yds.	Per Cu. Yd.
Dry excavation	10,515,443	$0.0795
Wet excavation	5,274,633	0.0713
Concrete	565,459	0.1741
Sand	316,028	0.2789
Stone	581,812	0.2410
Dry fill	1,913,963	0.0065
Wet fill	1,556,745	0.0587

The compartment type of rock car is now being used by the Los Angeles Pacific Railway Co., and it has proved very successful. In this type of car a box is built on an ordinary flat car having a floor raised about 2 feet along the center line of the car and sloping to each side. This box is divided into twelve or more compartments, each having two doors, one on each side of the car. The teamster drives his wagon along the side of the car and adjusts a board between his wagon and the car which prevents the spilling of any rock on the ground. He then, with his shovel, loosens the hook holding the door in place, which allows it to swing up and discharge the whole two yards which each compartment contains. The whole operation is consummated in about one minute. Mr. H. R. Postle gives the following bill of lumber for building such a box on a 34-foot flat car:

6—2 x 4 in. x 18 ft.	12—4 x 4 in. x 8 ft.
6—4 x 6 in. x 16 ft.	4—2 x 16 in. x 16 ft.
60—2 x 12 in. x 16 ft.	

Total, 2,643 ft. at $22 per M ft. = $58.15.

He does not give the amount of bolts and iron required, but says that the shop foreman of the railroad told him that each car costs a total of $250.

CARTS

Dump carts, one horse, with three-inch tires, cost:

	Capacity, Cu. Ft.	Pounds	Weight, Lbs.	Price
Light cart	21	2,500	700	$42.00
Heavy cart	24	3,500	900	45.00

For hoppers 10 inches deep add	$9.50
For tail gate add	2.00
For automatic end gate add	8.50
For 4-inch tires add	5.50
For steel bottom add	5.00

Ten new railroad, one-horse dump carts, some with steel and some with wooden bottoms, cost $50 each. Repairs cost $1.75 per month each during eighteen months' use. Six old carts about two years old averaged $2 per month for repairs for twelve months. Other carts also averaged $2. The life of wooden dump carts is about five years.

Fig. 54.

Mr. D. J. Hauer says that average dump carts, without a tail-board, hold about 0.6 cu. yds. of earth, or 0.35 cu. yds. of rock, place measure.

From Morris's data, quoted by Mr. H. P. Gillette in "Earth Work and Its Cost," the average speed of a cart is 200 feet per minute and the average load ⅓ cubic yard on a level and ¼ cubic yard on steep ascents such as when making railroad fills; and the lost time for each trip in loading and dumping averages four minutes; these data having been obtained on some 150,000 yards of work.

In a great deal of one-horse cart work it can be so arranged that one driver attends to two carts, the undriven horse being trained in a very few days to follow his leader.

Concrete spreader carts similar to Fig. 55, having a capacity of 21 cubic feet and weighing 985 pounds, cost $99.

Pick-up carts or beam trucks, having two wheels and a raised axle, are used for picking up and hauling iron pipe, timbers, structural shapes, etc.

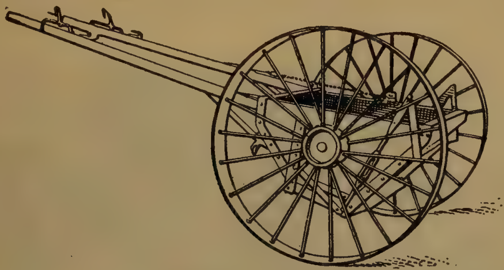


Fig. 55. Spreader.

They are usually drawn by hand.

Diameter of wheels, 40 ins.; weight, 400 lbs.; price..........$34
Diameter of wheels, 48 ins.; weight, 450 lbs.; price.......... 35
Diameter of wheels, 54 ins.; weight, 500 lbs.; price.......... 42

CEMENT SIDEWALK AND CURB FORMS

Adjustable steel sidewalk and curb forms are rapidly coming into use, and where the amount of work is large, their extra cost is justified.

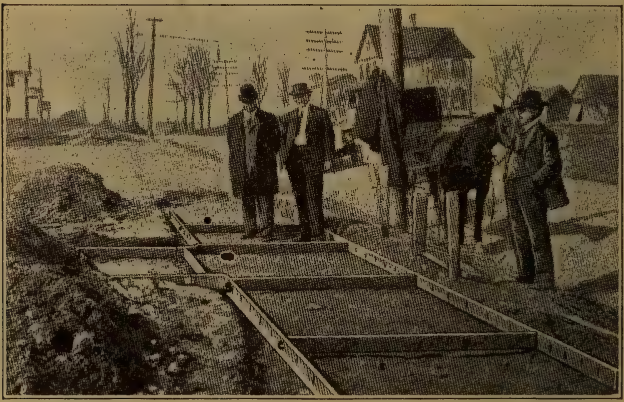


Fig. 56. This Cut Shows the Use of the 6-inch-radius Curve

TABLE 79—SIDE RAILS (RIGID)

10 ft. Rails, 4 in. high	$1.75
10 ft. Rails, 5 in. high	2.00
10 ft. Rails, 6 in. high	2.25
10 ft. Rails, 7 in. high	2.50
10 ft. Rails, 8 in. high	2.75
10 ft. Rails, 12 in. high	4.00
10 ft. Rails, 18 in. high	8.50
10 ft. Rails, 24 in. high	10.00

Rails shorter than 10 feet to be used in "ending up" work may be purchased at a cost proportionate to the 10 ft. lengths; i. e., a 5 ft. length would cost one-half the amount of a 10 ft. length.

Flexible side rails are made in any length to make any desired radius, at the same proportionate prices as the rigid side rails.

TABLE 80—SIDEWALK DIVISION PLATES

Width of Sidewalk	Cost of Plates 4" Depth	5" Depth	6" Depth
3 feet	$0.50	$0.65	$0.80
4 feet	.70	.85	1.05
5 feet	.85	1.05	1.30
6 feet	1.00	1.25	1.45

TABLE 81—COMBINED CURB AND GUTTER DIVIDING PLATES

Height of Curb	Thickness of Curb	Width of Gutter	Cost
12″	5″	12″	$0.65
12″	6″	18″	.75
12″	6″	24″	.90
12″	6″	30″	1.15
12″	6″	36″	1.40

Fig. 57.

TABLE 82—CURB DIVIDING PLATES

Height of Curb	Thickness of Curb	Cost
12″	5″	$0.40
12″	6″	.40
16″	6″	.50
18″	6″	.55
24″	6″	.75

Cement Workers Tools. The following are net prices at Chicago for tools used in constructing and finishing cement sidewalks. The prices are for iron nickel plated tools.

JOINTER

2¾ in. wide, 6 in. long, each....................$0.54

NARROW JOINTER

1¾ in. wide, 8 in. long, ½ in. blade, each....................$0.60
1¾ in. wide, 8 in. long, ¼ in. blade, each.................... .60

STRAIGHT END JOINTER

3 in. wide, 6 in. long, ½ in. deep, each $0.60

NARROW STRAIGHT END JOINTER

1¾ in. wide, 8 in. long, ½ in. blade, each $0.60
1¾ in. wide, 8 in. long, ¼ in. blade, each .... .60

DRIVEWAY GROOVER

The following are net prices for driveway groovers, 3 in. wide and 9 in. long:

Groover, ¾ in. deep, each $1.10
Groover, half round, each 1.10
A 6-in. V-groover, ⅝ in. wide, ½ in. deep, costs 52 cts. each.

STRAIGHT END GROOVER

6-in. V-groover, ⅝ in. wide, ½ in. deep, each $0.60

EDGERS

The net prices of edgers, ⅜ in., 2¾ in. and 6 in. long, are as follows:

¾ in. turned edger, each $0.52
¾ in. turned edger, 10 in. long, each 1.35

NARROW EDGER

8 in. long, 1¾ in. wide, each $0.60
6 in. long, 1½ in. wide, with guide .... .52
A reversible handle edger, right or left, 1 in. turned edge, ¾ in. radius, 3 in. wide and 6 in. long, costs 60 cts.

CIRCLE EDGERS

⅝-in. radius, each $0.45
¾-in. radius, each .... .45

A square edger 3 ins. wide, 6 ins. long, both edges rounded, with 1½-in. cutting edge, costs 75 cts. Bevel edgers, 2¾ ins. wide, 6 ins. long, with either ⅜-in. bevel or ⅝-in. bevel, can be bought at 53 cts. each. Corner tools, one end straight, the other curving back, 6 in. long, 1½ ins. wide, also cost 53 cts. each. Curbing edgers with 2 in. turned back with radius of 1½ ins., 3½ ins. wide, 6½ in. long, cost $1.09 each. Raised (tuck) pointers, $\frac{3}{16}$, ¼, $\frac{5}{16}$, ⅜ or ½-in. size, cost 45 cts. each.

Long handled finishing tools cost as follows:

Trowel with one long adjustable handle, one short handle, one wrench; price, 15 in., $4; 24 in., $6. Jointer, with one long handle, one short handle, one wrench; price, $4. Edger, same equipment, $4. Six-ft. compasses, $3.50.

CEMENT TESTING APPARATUS

On large concrete jobs it is desirable that all cement shall be tested. The usual practice is to engage a specialist, who sends a representative to obtain samples from the job for testing at his own laboratory. This is undoubtedly the best way, but where work is located far from large cities testing in this manner is very expensive. The way this difficulty is generally overcome is by selecting samples from the cars immediately before they leave the factory and then sealing the cars. On work where these methods cannot be used, a field laboratory can be installed.

Such a laboratory, exclusive of the building, water supply, and few pieces of furniture will cost as follows:

1 Cement testing machine	$135.00
Or 1 Improved cement testing machine	185.00
1 Percentage scale ½ to 16 oz.; 0 to 100%	5.40
1 Even balance scale with brass weights	6.75
2 3-section gang molds @ $10.80	21.60
1 Ground glass plate, 24"x24"	8.10
1 Galvanized iron pan, 24"x24"x3" deep	1.80
1 Set Gilmore needles	4.50
1 16 oz. measuring glass	.90
1 Small trowel	.70
1 Large trowel	.90
1 Set cement test sieves, 50, 100 and 200, with lid and bottom, brass	13.50
1 Set sand test sieves, 20, 30, with lid and bottom, brass	7.00
Total, $256.15, or	$206.15
Shipping weight, 600 pounds, or	500 lbs.

Where any considerable amount of testing is to be done several more gang molds with some sort of damp closet are desirable, costing an extra $30 or $40.

CHAIN BELTS

(See Belting for Power Purposes.)

CHAINS

Chains possess about ⅔ the strength of single bars of iron. They should be very carefully tested, as one weak link means that the whole chain is weak. The diameter of sheaves or drums should not be less than thirty times the diameter of the chain iron used, and for hoisting purposes, chains should be of short links with oval sides. The life of a chain is greatly increased by frequent lubricating and annealing.

B. B. Crane chain is of refined iron having a tensile strength of 48,000 pounds per square inch, and is for ordinary use. B. B. B. Crane chain is of iron of 50,000 pounds per square inch tensile strength.

Special Dredge chain is of iron of 53,000 pounds per square inch tensile strength. In the following table the safe load should be taken as ⅔ the "proof." The breaking strength is about double the "proof."

TABLE 83

	CLOSE LINK CHAIN						STUD LINK					
Size in Ins.	Average Weight per Foot in Lbs.	Proof Test in Pounds — B. B. Crane	Proof Test in Pounds — B. B. B. Crane	Proof Test in Pounds — Best Special Dredge	Outside Dimensions Ins. Length	Outside Dimensions Ins. Width	Average Weight per Fathom	Outside Dimensions Ins. Length	Outside Dimensions Ins. Width	Proof Test, Pounds	Breaking Strain, Pounds	Length Six Links Ins.
1/4	3/4	1,500	2,000	2,500	1 5/16	7/8	...	....	...	......	......	....
5/16	1	2,500	3,000	3,500	1 1/2	1 1/16	...	....	...	......	......	....
3/8	1 1/2	4,000	4,500	5,000	1 3/4	1 1/4	...	....	...	......	......	....
7/16	2	6,000	6,500	7,000	2 1/16	1 3/8	...	....	...	......	......	....
1/2	2 1/2	7,000	8,000	9,000	2 3/8	1 11/16	14	3	1 3/4	9,500	15,500	13
9/16	3 1/6	9,000	10,000	11,000	2 5/8	1 7/8	18	3 3/8	2	11,750	18,500	14 5/8
5/8	4 1/3	11,000	12,000	14,000	3	2 1/16	24	3 3/4	2 1/4	12,500	22,000	16 1/4
11/16	5 1/3	14,000	14,500	17,000	3 1/4	2 1/4	29	4	2 1/2	17,000	28,000	17 1/8
3/4	6 1/6	16,000	17,500	20,000	3 1/2	2 1/2	34	4 3/8	2 3/4	20,250	32,000	18 3/4
13/16	7	19,000	20,000	23,000	3 3/4	2 11/16	40	4 3/4	3	23,750	36,000	20 3/8
7/8	8	20,000	22,000	26,000	4	2 7/8	44	5	3 1/4	28,000	42,000	21 1/4
15/16	9 1/6	24,000	25,000	29,000	4 3/8	3 1/16	51	5 3/8	3 1/2	31,600	48,000	22 7/8
1	10 1/2	26,000	28,000	32,000	4 5/8	3 1/4	59	5 7/8	3 3/4	36,000	54,000	25 1/4
1 1/16	12	28,000	32,000	35,000	4 7/8	3 5/16	66	6 1/4	3 7/8	40,600	62,000	26 7/8
1 1/8	13 1/6	32,000	36,000	40,000	5 1/8	3 3/4	75	6 1/2	4 1/8	45,500	70,000	27 3/4
1 3/16	14 2/3	36,000	40,000	46,000	5 9/16	3 7/8	82	6 3/4	4 1/4	50,750	76,000	28 5/8
1 1/4	16 2/3	42,000	44,000	51,000	5 3/4	4 1/8	91	7 1/8	4 1/2	56,250	86,000	30 1/4
1 5/16	17 1/2	46,000	48,000	54,000	6 1/8	4 1/4	100	7 3/8	4 5/8	62,000	94,000	31 1/8
1 3/8	19 2/3	50,000	53,000	58,000	6 7/16	4 9/16	110	7 3/4	4 7/8	68,000	102,000	32 3/4
1 7/16	21 1/6	54,000	58,000	62,000	6 11/16	4 3/4	120	8 1/8	5 1/8	74,250	112,400	34 3/8
1 1/2	23	60,000	62,000	67,000	7	5	132	8 1/2	5 3/8	81,000	118,000	36
1 9/16	25 1/6	64,000	66,000	70,500	7 3/8	5 5/16	142	8 7/8	5 5/8	87,800	124,000	37 5/8
1 5/8	28	70,000	72,000	77,000	7 3/4	5 1/2	150	9 1/4	5 7/8	95,050	134,000	39 1/4
1 11/16	30	......	75,000	79,000	8 1/8	5 11/16	162	9 5/8	6	102,500	144,000	40 7/8
1 3/4	32	......	78,000	83,000	8 1/2	5 7/8	175	10	6 1/4	110,250	156,000	42 1/2
1 13/16	33	......	84,000	89,000	8 7/8	6 1/16	188	10 1/4	6 1/2	118,250	166,000	43 3/8
1 7/8	35	......	90,000	95,000	9 1/4	6 3/8	200	10 1/2	6 3/4	126,500	178,000	44 1/4
1 15/16	38	......	95,000	101,000	9 5/8	6 9/16	215	10 3/4	7	135,000	190,000	45 1/8
2	40	......	102,000	108,000	10	6 3/4	229	11 1/8	7 1/4	144,000	202,000	46 3/4
2 1/16	43	......	108,000	115,000	10 3/8	6 15/16	243	11 1/2	7 1/2	153,000	216,000	48 3/8
2 1/8	47	......	115,000	122,000	10 3/4	7 1/8	258	12	7 3/4	162,500	228,000	50 3/4
2 3/16	50	......	121,000	129,000	11 1/8	7 5/16	273	12 1/2	8	172,250	242,000	53 1/8
2 1/4	53	......	128,000	136,500	11 1/2	7 5/8	289	13	8 1/4	182,250	256,000	55 1/2
2 3/8	58 1/2	......	140,000	152,000	11 7/8	8	320	13 1/2	8 3/4	203,000	286,000	57 1/4
2 1/2	..	......	......	......	..	..	355	14	9	225,000	316,000	59

HAND MADE, HIGH GRADE CHAIN COSTS (APPROXIMATE) PER POUND

Size	Special Dredge	B. B. B. Crane	B. B. Crane
½"	$0.10	$0.09	$0.08
¾"	.08	.07	.06
1"	.07	.058	.053
1¼"	.062	.053	.05

PIPE OR STONE CHAINS WITH HOOK AND RING COST

⅜ inch	12 foot length	$2.90
½ inch	12 foot length	4.10
⅝ inch	15 foot length	5.25
¾ inch	15 foot length	6.75

Log Chains, 15′ long, heavy, short link, $\frac{7}{16}$" swivel in center; weight, 30 lbs.; price, $3.25.

TABLE 84
STRENGTH AND WEIGHT OF CLOSE LINK CRANE CHAINS, AND SIZES OF EQUIVALENT HEMP CABLES (UNWIN).

Diameter of Iron in Inches	Weight in Lbs. per Fathom	Breaking Strength in Tons	Testing Load in Tons	Girth of Equivalent Rope in Ins.	Wt. of Rope in Lbs. per Fathom
¼	3.5	1.9	.75	2	1⅜
$\frac{5}{16}$	6.0	3.0	1.1	2½	1½
⅜	8.5	4.3	1.6	3¼	2½
$\frac{7}{16}$	11.0	5.9	2.3	4	3¾
½	14.0	7.7	3.0	4¾	5
$\frac{9}{16}$	18.0	9.7	3.8	5½	7
⅝	24.	12.0	4.6	6¼	8½
$\frac{11}{16}$	28.	14.6	5.6	7	10½
¾	31.5	17.3	6.8	7½	12
$\frac{13}{16}$	37.	20.4	7.9	8¼	15
⅞	44.	23.1	9.1	9	17½
$\frac{15}{16}$	50.	26.1	10.5	9½	19½
1	56.	29.3	12.	10	22
1⅛	71.	36.3	15.3	11¼	27¾
1¼	87.5	44.1	18.8	12½	34½
1⅜	105.8	52.8	22.6	13¾	41½
1½	126.	62.3	27.	15	49½

TABLE 85
STRENGTH AND WEIGHT OF STUDDED LINK CABLE (UNWIN).

Diameter of Iron in Inches	Weight in Lbs. per Fathom	Breaking Strength in Tons	Testing Load in Tons	Girth of Equivalent Rope in Ins.	Wt. of Rope in Lbs. per Fathom
⅝	24.	9.5	7.	6½	9
$\frac{11}{16}$	28.	11.4	8.½	7½	12
¾	32.	13.5	10.½	8	14
⅞	44.	20.4	13.¾	9½	19½
1	58.	24.3	18.	10½	22½
1⅛	72.	29.5	23.¾	12	30¾
1¼	90.	38.5	28.½	13½	39¼
1⅜	110.	48.5	34.	15	48¼
1½	125.	59.5	40.½	16	55
1⅝	145.	66.5	47.½	17	62
1¾	170.	74.1	55.⅛	18	68¼
1⅞	195.	92.9	63.¼	20	86
2	230.	99.5	72.	22	104
2⅛	256.	112.0	81.¼	24	124
2¼	285.	126.0	91.⅛	26	145

CHAIN BLOCKS

For moving loads vertically where great power is not obtainable and speed is not a requisite, chain blocks are the best means. These are made in three types, triplex, duplex and differential.

Fig. 58.

These are made in three types, triplex, duplex and differential. 82 pounds and overhauls 31 feet of chain, with the duplex he pulls 87 pounds and overhauls 59 feet of chain, and with the differential three men pull 216 pounds and overhaul 30 feet of chain.

TRIPLEX BLOCKS
TABLE 86

Capacity in Tons	Hoist in Feet	Weight, Lbs. (Net)	Price	Extra Hoist per Ft.
½	8	53	$ 28.00	$0.72
1	8	80	36.00	.76
1½	8	124	48.00	.80
2	9	188	56.00	.84
3	10	200	72.00	1.20
4	10	290	88.00	1.28
5	12	380	112.00	1.72
6	12	390	132.00	1.72
8	12	470	160.00	2.16
10	12	570	192.00	2.60
12	12	800	240.00	3.44
16	12	1,000	288.00	4.32
20	12	1,375	315.00	5.20

Sizes 3 to 20 tons have a lower as well as an upper block.

DUPLEX BLOCKS

TABLE 87

Capacity in Tons	Hoist in Feet	Weight, Lbs. (Net)	Price	Extra Hoist per Ft.
½	8	43	$ 21.25	$1.00
1	8	57	25.50	1.27
1½	8	76	34.00	1.50
2	9	104	42.50	1.70
3	10	200	63.75	1.85
4	10	225	80.75	2.05
5	12	340	119.00	2.55
6	12	360	153.00	3.20
8	12	390	178.50	3.40
10	12	570	232.75	3.60

DIFFERENTIAL BLOCKS

TABLE 88

Capacity in Tons	Hoist in Feet	Weight, Lbs. (Net)	Price	Extra Hoist per Ft.
⅛	5	11	$ 9.00	$1.40
¼	6	22	9.00	1.40
½	7	30	10.50	1.40
1	8	51	14.00	1.50
1½	8½	81	18.00	1.60
2	9	122	22.50	1.70
3	9½	180	30.00	2.00

Chain blocks kept well oiled and kept under cover where grit and dirt cannot enter the gears should have a life of from five to twenty years. On outside work where sand and grit is allowed to enter the gears the life of a block is reduced very much, and repairs may cost as much as 50 per cent of the first cost annually.

CHUTES

Chutes for stone or, in fact, almost any material must be lined with sheet iron or steel to prevent excessive wear. Sooner or later a hole wears in these sheets and it is then necessary to renew the entire piece.

Witherbee, Sherman & Co., at Mineville, N. Y., use bar steel for lining their ore chutes. The bars are ¾x6 inches in size, and when worn are replaced by a new piece. In this way no steel is wasted and the time spent in repairs is much lessened.

Dolese & Shepard, in their new stone-crushing plant in Chicago, at all points where the crushed stone drops, have made pockets where a certain amount of the material collects, and saves the chutes and bins from excessive wear at these points.

Angle extension wagon chutes for hard and soft coal may be economically used in construction work for placing concrete and transporting other materials. They are adapted to indefinite extension, but each section is in itself an independent chute. The prices of chutes 18 ins. wide at top and 17 ins. at foot, made of No. 18 black sheet steel with heavy end bands, weighing about 5½ lbs. per foot, are as follows:

5 ft. lengths, each	$2.50	10 ft. lengths, each	$5.00
6 ft. lengths, each	3.00	12 ft. lengths, each	6.00
8 ft. lengths, each	4.00		

CAR CHUTE

A chute constructed of sheet steel and angle iron so as to hook on any car or wagon is made in three stock sizes and in many cases effects great saving in the cost of unloading material from cars. (See Fig. 59.)

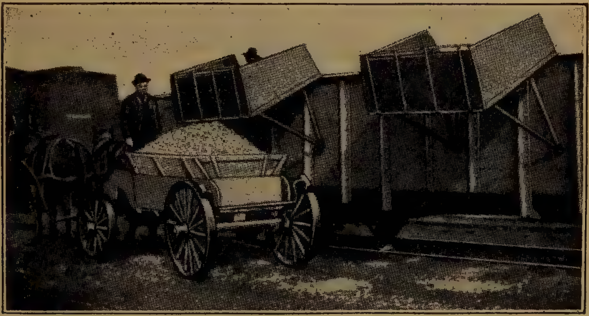


Fig. 59.

	Weight	Price
¾ yard capacity or ½ ton of coal	250 lbs.	$40.00
1 yard capacity or ¾ ton of coal	275 lbs.	50.00
1½ yard capacity or 1 ton of coal	325 lbs.	60.00

Rated as fourth class freight

Another chute, or "Adjustable Car-side Hopper," is so arranged that the front can be adjusted to any convenient height, and can be emptied gradually or the discharge cut off entirely. (See Fig. 60.)

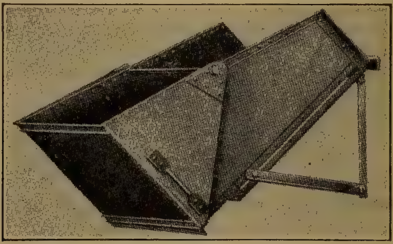


Fig. 60.

Capacity Cu. Ft.	Weight, Lbs.	Price
20	600	$45.00
30	700	54.00
45	975	67.50

CLOTHING

Rubber coats, $3 to $6.

OILED CLOTHING

PRICE PER DOZEN

	Yellow	Black
Slickers	$16.00 to $25.00	$17.00 to $26.00
Long Coats	20.00 to 24.00	21.00 to 26.00
Medium long	14.00 to 20.00	15.00 to 22.00
Jackets	8.50 to 12.00	9.00 to 13.00
Pants	8.40 to 12.00	9.00 to 13.00
Hats	2.50 to 3.50	2.50 to 3.50

CONVEYORS

(See Excavators)

Belt conveyors were first used in 1868 and since that date have attained great popularity as a means of conveying all sorts of solid materials. The great advantages of belt conveyors are the small horsepower required to drive them, their noiseless operation and large capacity.

Power Required. In a concrete mixing plant in New York City a belt conveyor 24 inches wide, traveling at a speed of 400 feet per minute, and carrying the concrete from the mixer to the forms, required but 1 horsepower to drive it. The belt which

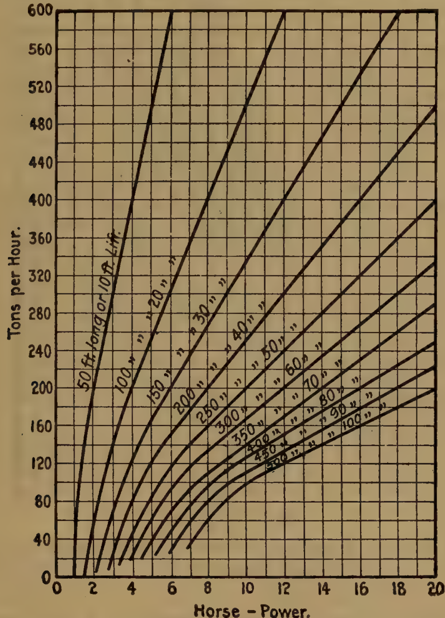


Fig. 61. Diagram Showing Power to Operate Belt Conveyors.

carried the materials to the mixer was 20 inches wide, 228 feet long and had a rise of 34 feet. It traveled at a speed of 350 feet per minute and required but 6 horsepower to drive it with its load of 100 tons per hour. In the Transvaal a belt with a horizontal carry of 200 feet and a vertical lift of 48½ feet, con-

veying 71.4 tons per hour, required 8.1 horsepower to drive it. A belt with a horizontal carry of 500 feet and a vertical lift of 25½ feet required 8.6 horsepower to convey 90 tons per hour, and 2.9 horsepower to drive the unloaded belt.

The capacity of belt conveyors is shown in two diagrams (Figs. 61 and 62), published by Mr. R. W. Dull in the *Chemical*

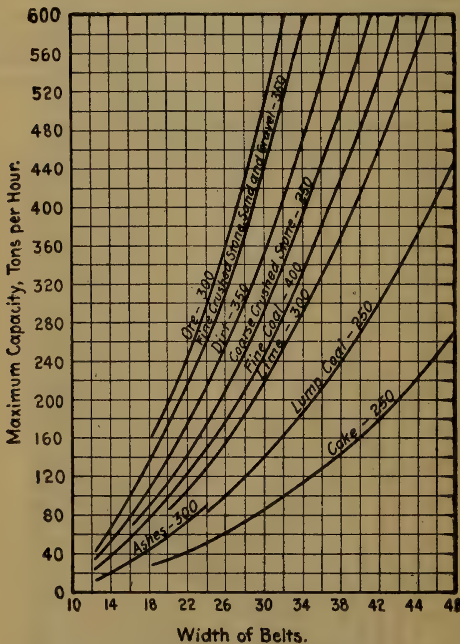


Fig. 62. Diagram Showing Capacity of Belt Conveyors.

Engineer, August, 1909. These are based on good feeding conditions and variations as great as 50 per cent are likely. Some of the curves are stopped off at certain sized belts, as with large pieces it is not advisable to use a conveyor any narrower, regardless of what capacity is required. It is advantageous to install a feeding device of some kind if the feed is irregular. Materials should be delivered to the belt in the direction of motion of the belt and with as near the same velocity as possible.

Wear. Small belts of stitched canvas or woven cotton are often used and are usually well oiled. For large, permanent con-

veyors, rubber belts composed on a cotton duck foundation are most satisfactory. Mr. George Frederick Zimmer in *Cassier's Magazine* for August, 1909, gives the following table showing the wear on different materials subjected to a uniform sand blast for 45 minutes:

Rubber belt	1.0
Rolled steel	1.5
Cast iron	3.5
Balata belt, including gum cover	5.0
Woven cotton belt, high grade	6.5
Stitched duck, high grade	8.0
Woven cotton belt, low grade	9.0

The rubber covering performs two offices, that of resisting wear and that of preventing moisture from reaching the body of the belt.

The number of plies necessary is given by Mr. C. K. Baldwin. Belts 12 to 14 inches wide, not less than 3-ply; 16 to 20 inches wide, not less than 4-ply; 22 to 28 inches, not less than 5-ply, and 30 to 36 inches, not less than 6-ply. The tension on a belt must not be more than 20 to 25 lbs. per inch per ply and a good belt should have a breaking strain of 400 lbs. per inch per ply.

Belts are usually troughed because this increases the capacity. A sufficient number of idlers should be provided, as this lessens the chance of damage. Idlers should be kept well lubricated with a viscous lubricant as oil is liable to spill on the belt. The best method of joining belts is with a butt-joint held together by clamps.

Costs. For contract purposes the belt conveyor is generally mounted on a more or less elaborate wooden framework, housed or otherwise, the cost of which must be estimated in accordance with the special conditions and design of the outfit. The belt conveying apparatus proper consists of a driving mechanism, which is often belted or sometimes directly connected to electric motors; the idlers and belts; and the troughing rollers. The price will vary considerably, approximate ones only being here given for purposes of rough estimates.

TABLE 89

Width of Belt	Maximum Diam. of Lumps of Material	Speed	Weight per Ft. for Belt, Return Idlers and Troughing	Approximate Cost per Lineal Ft.*
12″	2″	Up to 200 ft. per minute	14 lbs.	$ 2.50 to $ 4.00
18″	4″	Up to 200 ft. per minute	30 lbs.	4.00 to 6.25
24″	6″	Up to 200 ft. per minute	46 lbs.	5.75 to 8.75
7″	7″	Up to 200 ft. per minute	62 lbs.	7.25 to 11.75
6″	9″	Up to 200 ft. per minute	100 lbs.	10.50 to 14.25

*Depends upon kind of belt.

Note. At speed of 300 ft. per minute a 12″ belt should not carry material more than ½″ in diameter; 8″ belt, material not more than 1½″ in diameter; 24″ belt, not larger than 3″; 30″ belt, not larger than 4″; 36″ belt, not larger than 6″ in diameter.

When speeds up to 600 ft. per minute are used material larger than 2″ size is not likely to stay upon the large belts and for material 1″ and larger a belt no smaller than 18″ should be used.

W. R. Ingalls says that the cost of a 12″ belt plant capable of running at 300 ft. per minute would be about $600 for lengths of 100 ft. each, and if properly installed would consume about 3 to 3½ horsepower. He says that the cost of repairs should be about 12½ per cent per annum upon the cost of plant if given such service that the belt will last about five years; while if the belt is so used as to last only 2½ years the repair cost must run up to about 20 per cent per annum. In one actual case in a plant where many belt conveyors were used repairs did not average more than 12½ per cent.

Mr. George F. Zimmer is an English authority for the statement that the cost of repairs for 100 ft. of traverse varies from ¾c to 1c per ton per 100 ft. for coal, to 2c for coke and 8c for sulphate of ammonia. These figures are given also in the table following.

TABLE 90—VARIOUS TYPES OF CONVEYORS.

TABLE OF FIRST COST, TONS OF MATERIAL TRANSPORTED, COST OF REPAIRS AND RENEWALS, ETC.

Apparatus	First Cost Total	First Cost Per Lin. Ft.	Tons of Material Trans-ported.	Distance of Traverse	Cost of Repairs and Renewals Total Cost	Per Ton	Per Ton for 100 Ft. Traverse	Description of Material Conveyed
Elevator	$7,555.00	$20.36	335,237	74	$ 418.86	.122	.164	Coal
Elevator	3,982.00	30.54	178,541	58 & 72	3,305.86	1.826	2.810	Part hot coke
Elevator	2,080.00	25.89	37,685	40	35.41	.92	.230	Oxide of iron and lime
Push plate conveyor..	1,439.00	11.75	149,350	30	342.00	.226	.754	Coal
Push plate conveyor..	7,222.00	25.00	29,769	90	537.98	1.782	1.876	Hot coke
Plate belt conveyor..	9,859.53	17.29	149,350	90, 106, 125, 125, 125, 125, 60	11,246.48	7.428	4.140	Hot coke
Canvas belt	2,755.86	23.30	10,000	98	194.00	2	2	Small coke
Belt conveyor.......	1,440.50	11.75	149,350	30	342.00	.226	.754	Coal
Belt conveyor.......	799.03	6.88	2,180	110	224.64	9.26	8.42	Sulphate of ammonia
Swinging	8,215.31	4.86	250,000	21	73 00	.228	.0006	Coal

Conveyors total length, 1,722 ft.

Mr. Edwin H. Messiter says that for ordinary mine run ore the largest lumps of which do not contain over 1 cubic foot, a 30″ conveyor is suitable. Sizes of lumps which may be carried by the several sizes of conveyors are:

Lumps	Conveyor	*Tons per Hour
12″	30″	560
8″	24″	360
6″	20″	250
4″	16″	160
3″	14″	120
2″	12″	80

Speeds up to 400 ft. per minute may be used and 700 ft. in special cases.

Inclination should be limited to 20° from horizontal, but 26° may be used with steady feed and fine material. Life of belts varies with tonnage. If correctly designed and made of proper materials on large conveyors, belt renewals will approximate 0.1c. per ton of ore. Cost is greater on small conveyors than on large ones. Horsepower required will average about 0.00015 horsepower per ton per foot of horizontal distance carried, plus 0.001 horsepower ton per foot of height elevated.

Automatic reversible trippers are designed to distribute material carried by belt conveyors on long piles or large bins. They travel on a track between two points, automatically reversing and discharging their load continuously. They can be so regulated as to discharge at one point. Their cost is about as follows:

Width of Belt, Inches	Price	Width of Belt, Inches	Price
12	$320	20	$425
14	345	24	475
16	370	30	555
18	345	36	635

Hand propelled trippers discharge materials at fixed points, to which they are moved along a track by hand.

Width of Belt, Inches	Price	Width of Belt, Inches	Price
12	$180	18	$215
14	190	20	225
16	200	24	250

*Last column is capacity for ore weighing 100 lbs. per cubic foot at a speed of 400 feet per minute.

TROUGHING AND RETURN IDLERS.

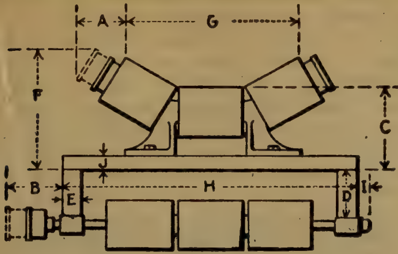


Fig. 63.

DIMENSIONS IN INCHES

Width of Belts	A	B	C	D*	E†	F	G	H	I
12	11⅛	5	7¾	3⅝	3	11½	12	22	1 1/16
14	12¼	5	7¾	3⅝	3	12½	14½	24	1 1/16
16	13⅛	5	7¾	3⅝	3	12½	16½	26	1 1/16
18	13⅝	5½	9¼	3⅞	5	13¾	18	32	1¼
20	15⅜	5½	9¼	3⅞	5	13¾	20½	34	1¼
24	16½	5½	9¼	3⅞	5	14½	24⅝	40	1¼
30	18⅞	5½	10¼	4½	5	16	31⅝	46	1¼
36	21⅝	5½	12¼	5	5	18¼	37⅛	52	1⅝

Pulleys are of cast iron on hollow steel shafts, turning in cast iron brackets mounted on hard pine or steel base, for attaching to stringers.

Guide idlers are of cast iron and consist of two inclined pulleys mounted on cast iron brackets.

Width of Belt, Inches	Troughing Idlers	Return Idlers	Guide Idlers
12	$ 3.25	$3.10	$3.70
14	3.70	3.30	3.70
16	4.25	4.25	3.70
18	5.80	5.10	4.60
20	6.40	5.50	4.60
24	7.70	7.00	4.60
30	9.60	7.30	5.20
36	12.75	8.50	5.75

A bucket conveyor, with 18"x24" buckets capable of running at a speed of 10 ft. per minute, should cost about $3,600 per 100 ft. length, which includes the driving mechanism and an electric motor. The power needed to operate, about 1 horsepower; repairs and renewals for a number of years would average from 1 to 2 per cent per annum on the first cost. This of course does not include depreciation. For this opinion I am indebted to W. R. Ingalls, who has been quoted above.

Mr. F. W. Parsons is authority for the statement that a conveyor 95 ft. long and a cross conveyor 71 ft. long for conveying

* Minimum depth of stringer allowable with Standard Idler Boards.
† Maximum width of stringer allowable with Standard Idler Boards.

coal into a boiler house, including miter gears, countershaft, self-oiling pillow block, sprockets, etc., should cost about $475 f. o. b. factory. For driving machinery from main shaft to countershaft and from countershaft to lead shaft $75 ought to be added to this, and $175 for lumber, bolts and iron for chutes, and $200 for erection, total cost, exclusive of freight, being $915.

Belt elevator. The life of belts of the same grade varies widely between limits according to tonnage carried, the length of belts, and the economic layout of the whole arrangement. On large belts of course the cost for repairs per unit of material delivered will be considerably smaller than on small belts. For special work, such as crusher plants and outfits of similar kind, the operation is almost automatic and with the exception of renewals which can be made rapidly there is practically no interruption to continuous service.

Fig. 64.

At the Union Stock Yards in Chicago a belt carrier with 24"x24" buckets and a vertical lift of 58 feet with a 38-ft. horizontal run had been in operation about five years handling an average of 2,500 tons of coal per week, with no cost for repairs, and in 1908 was not likely to need repairs for another five years.

In Pittston, Pa., operating on a 25° incline and conveying coal 355 feet with 48" wide buckets, a belt carrier installed in 1902 handled 130,000 tons a month and after four years was in excellent condition. Cost of repairs averaged: material, .04c per ton handled; labor, .06c per ton handled, these repairs being the renewal of the carrier rollers and the driving pinion of the head gear.

The illustration (Fig. 64) shows a twenty-four inch conveyor

one hundred feet long supplied Charles F. McCabe by the Robins Conveying Belt Co., for removing 10,000 cubic yards of earth and rock at 181st street and Jerome avenue, New York. The picture shows the very disadvantageous circumstances under which such a belt conveyor will work to advantage. Earth was shoveled on to the conveyor by hand and was discharged from the head end to wagons. Pieces larger than a man's head were frequently placed on the conveyor, and were carried successfully, although it ran at times at an upward inclination of over 23 degrees. A Mundy engine, located in a pit beneath the tail end, drove the conveyor.

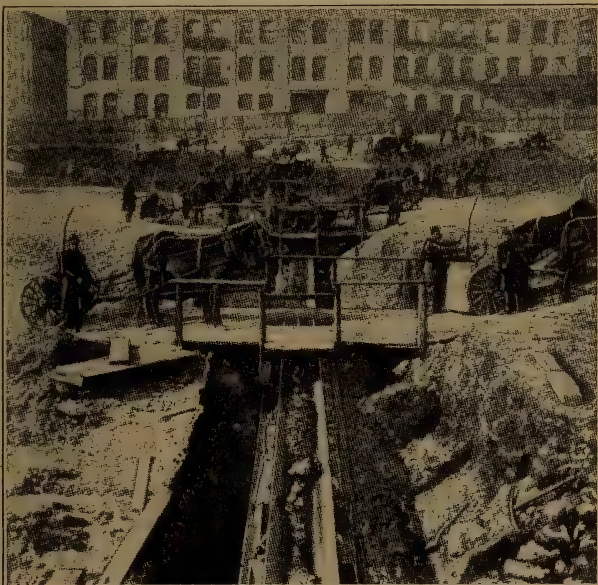


Fig. 65.

In the installation illustrated and described in the foregoing it was impossible to support the conveyor by any other than the most crude supports. This fact, however, did not interfere with the successful operation of the conveyor, nor did it injure the machinery to any appreciable extent. The belt itself, when the work was completed, showed little signs of wear.

Figure 65 shows a Robins Belt Conveyor used by Ryan & Parker in excavating for the foundation of the power house of the New York Gas and Electric Light, Heat and Power Co. The earth was delivered to the conveyor from wheel scrapers through

bridges, and the excavating was done by practically the same means, employed more recently by F. M. Stillman & Co., for their work at East 12th street, New York. The conveyor was driven at its head end by a small horizontal engine, very little power

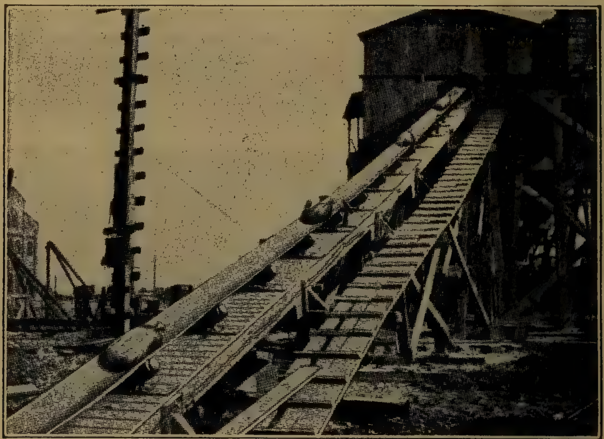


Fig. 66.

being required. It was subjected to the roughest kind of usage; rocks weighing over 100 pounds were constantly dumped upon it, but never caused a moment's stoppage during the entire work. The width of the belt was 30 inches, and the actual

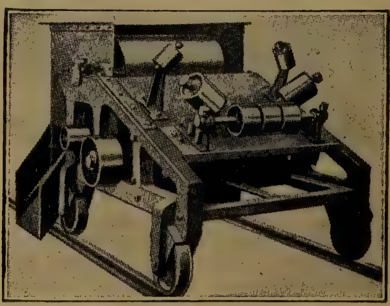


Fig. 67. Movable Tripper.

quantity removed exceeded 1,200 cubic yards per day. The work was all done during very cold weather, in December and January.

The conveyor used on this contract was also employed by

Messrs. Ryan and Parker for similar work in a great number of places, its length being increased or diminished as desired by easily made changes in the number of idlers and length of belt.

The illustration (Fig. 66) shows the conveyor described in the foregoing, carrying the cement bags up the incline to the mixer house. It was driven by a Lambert engine placed on a platform

Fig. 68.

in the mixer house, and run at a speed of 325 feet per minute. This engine also drove a 24-inch Robins Belt Conveyor which carried concrete from Smith mixers and discharged it through a long chute to cars, which carried the concrete to all points where foundations and retaining walls were being constructed. In order to prevent the material from adhering to the belt, a Robins high-speed rotary cleaning brush was attached to the discharge end of

the conveyor. This brush was belt driven from a small pulley on the shaft of the end pulley of the conveyor.

Hullett-McMyler Cantilever Crane or Conveyor. This machine is illustrated in Fig. 70 and was used on the Chicago Drainage Canal. The skip is of steel and has a capacity of 3.7 cubic yards water measure, or 1⅝ cubic yards of solid rock. A 9x12-inch engine working under 80 lb. pressure and with 200 revolutions

Fig. 69.

per minute does the hoisting. The total weight of the crane is 110 lbs. and its cost is about $9,000. The daily (10 hours) expense of operating each crane was:

1 engineer	$ 2.50
1 fireman	1.50
Machinist service	1.00
Superintendence	.75
1¼ tons coal	2.50
Oil and waste	.25
Repairs (?)	.50
Track maintenance	1.50
Night watchman	.50
Total	$11.00

The two handled 168,470 cubic yards solid rock in 337 10-hour shifts, 250 cubic yards per shift per machine.

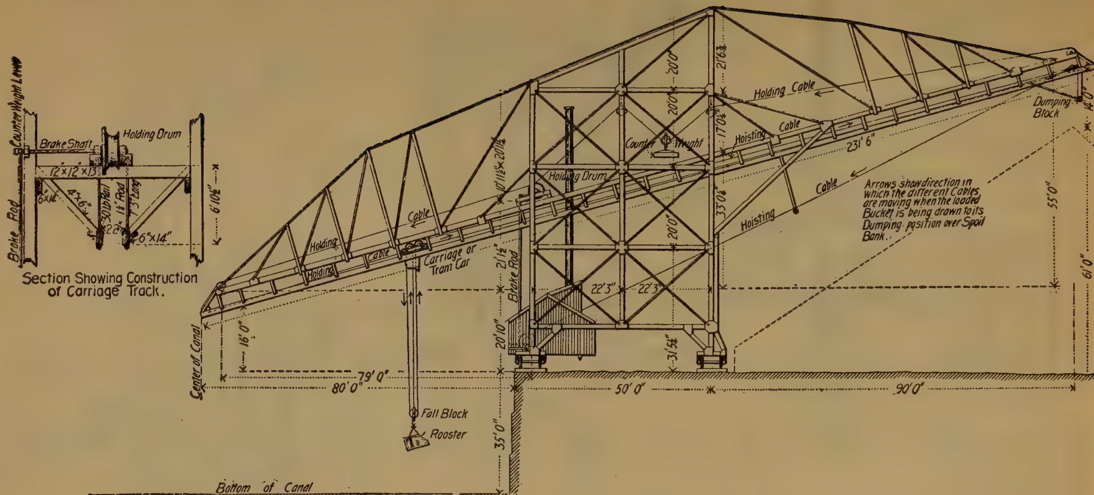


Fig. 70. Hulett-McMyler Conveyor for Conveying Rock on Section 7 of Chicago Main Drainage Canal.

Hullett-McMyler Derrick. Fig. 71 illustrates this machine, which handles a skip weighing 2,400 lbs., making, with its full load of 1⅝ cubic yards of solid rock, 3½ tons loaded. It weighs 95 tons and costs $15,000. The cost of operation is practically the same as for the Hullett-McMyler Conveyor. Two of these machines moved 279,300 cubic yards in 492 (10-hour) shifts averaging 568 cubic yards per shift for the two machines.

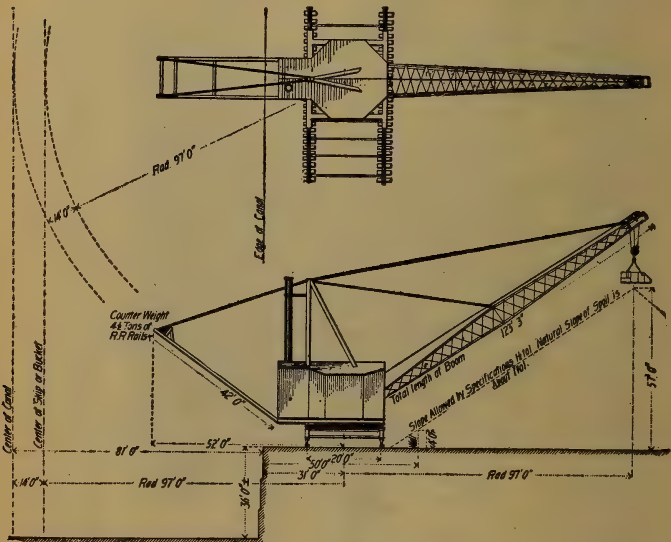
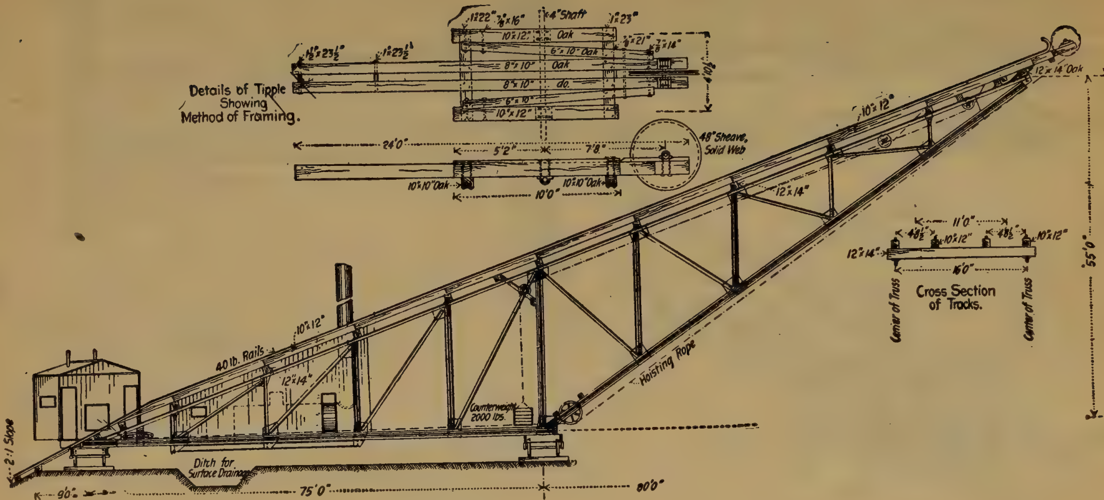


Fig. 71. Hulett-McMyler Derrick.

A steel incline and tipple is often used to convey earth from a steam shovel to the top of a high bank where it is dumped. Such a machine is illustrated in Figs. 72, 72A. The steel truss of the incline weighs 8,500 lbs., and the total load of boilers, without cars, etc., is 100 tons. The engines are 11"x18", double cylinders, and their cost with the boiler was $2,700. The shovel cut was 20 ft. wide, 18 ft. deep and the best month's record was 920 cubic yards per 10-hour shift. The whole machine cost about $4,000.



Side Elevation.

Fig. 72. Side Elevation of Steel Tipple.

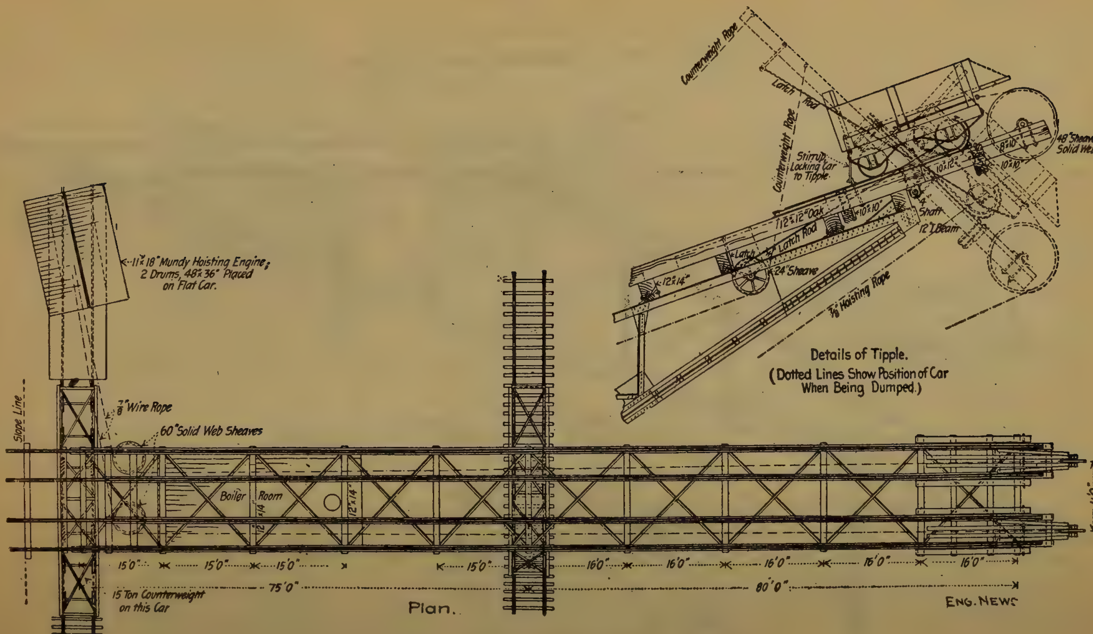


Fig. 72A. Ground Plan of Steel Tipple.

The Brown Cantilever Crane. Eleven of these machines shown in Fig. 73 were used on the Chicago Drainage Canal, and after the first year a monthly output of 15,000 to 16,000 cubic yards, 600 cubic yards per 10-hour shift per crane, was attained. The trusses have a slope of 12½°, a carriage or trolley travels along the track on the lower chord of the truss, the hoisting power being a 10½"x12" engine and a 120-horsepower boiler. The skip can be dumped automatically at any point. It has a capacity of 75 cubic feet water measure and carries 1.5 to 1.7 cubic yards of solid rock. The average traveling speed is 150 ft. per minute. The weight of the entire machine is 150 tons and it costs about $28,000. The daily cost of operating each crane was as follows:

Engineman	$ 3.00
Fireman	2.50
Oiler	1.75
Operator	2.75
1⅔ tons of coal at $1.75	3.00
Oil, water and waste (estimated)	.50
Laying track (estimated)	.50
Total	$14.00

MECHANICAL CONVEYORS.*

Mechanical conveyors, of which there is a great variety, may be classified as of (1) the push or drag type, and (2) the carrying type. In the former the material is pushed or dragged forward in a trough. In the latter type it is continuously carried forward on a belt, or in a series of connected pans or buckets, which take the place of a belt. In a horizontal conveyor the only mechanical work to be done consists in the overcoming of friction. It is obvious, therefore, that a well-mounted belt or series of buckets can be moved with less friction and therefore require less power than any form of conveyor in which the material has to be pushed or dragged forward.

All of these conveyors are used in practice, some of them extensively. Some of them are extremely efficient machines; others have very little to commend, yet are useful for some special purposes because of limitations in the application of better types. The special form of conveyor must always be chosen with view to the work that is to be done. In this article the writer has reference only to the use of conveyors for the transportation of ore and other mineral substances. There is a dearth of practical information on this subject; even the manufacturers appear to lack a good deal of important data, and it will be useful if readers are led to contribute results of their own experience. It is obviously a subject in which experiences may differ widely under varying conditions.

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* This article, by Mr. Walter Renton Ingalls, is so practical and so full of valuable data that it has been abstracted almost in full. It appeared in *The Engineering and Mining Journal* in 1904.

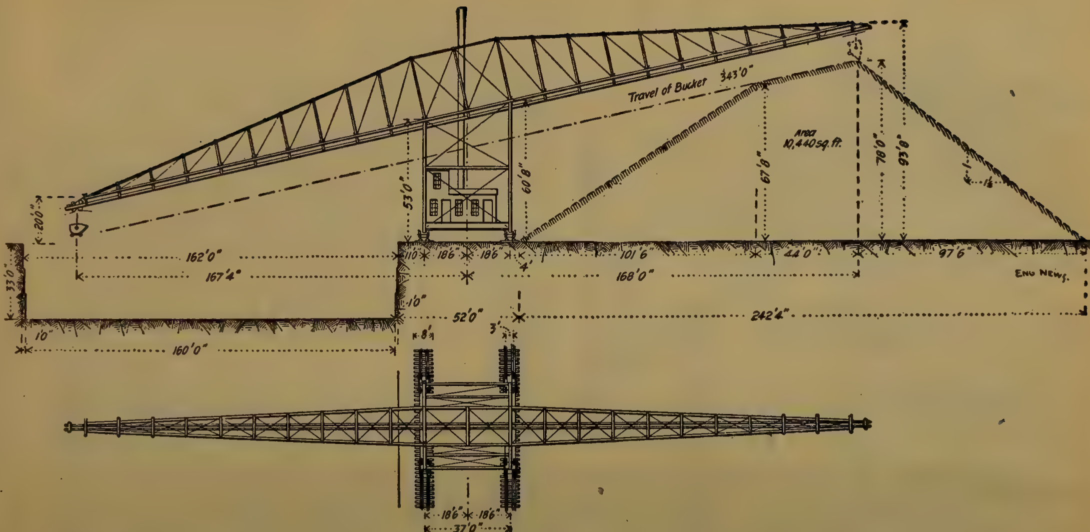

Fig. 73. Elevation and Plan of Brown Cantilever Crane.

Push or Drag Conveyors.

Among the conveyors of this type are the screw, the scraper, and the reciprocating. All of them have the advantage that material can be discharged without complicated machinery, at any desired point, which makes them especially useful for the filling of a series of bins.

Screw-Conveyor. The screw-conveyor is one of the oldest of conveying devices. Also it is perhaps one of the most inferior. The screw-conveyor consists commonly of a trough of iron or steel, with semi-cylindrical bottom, in which is turned an endless screw, composed of a shaft, solid or hollow, and a spiral of steel or cast iron. The shaft is supported in boxes at each end of the trough, and by intermediate hangers in long conveyors, and is driven by pulley, gear or sprocket wheel. The shaft is generally made in sections, which may be united in any suitable manner, though certain devices are much better than others. The spiral is ordinarily of 8-in., 10-in. or 12-in. diameter. In transporting ore it is inadvisable to turn a 9-in. or 10-in. screw at more than 50 to 75 rev. per min., since a higher speed is apt to throw material out of the trough and produce too much dust. Obviously the speed should diminish as the diameter of the screw increases.

The capacity of a screw-conveyor depends upon the diameter and pitch of the screw, its speed of revolution, and the specific gravity of the material to be transported. One manufacturer gives the capacity of a 6-in. screw, run at 100 rev. per min., at 3 tons per hour; of a 9-in. screw at 70 rev. per min., 8 tons per hour; and of a 12-in. screw at 50 rev., 15 tons per hour. It is presumable that these figures for capacity refer to quartzose ore, which may be taken as weighing 100 lbs. per cu. ft. Another manufacturer estimates the capacity of a 5⅞-in. screw at 120 rev., 42 cu. ft. per hour; 7⅞-in. at 110 rev., 71 cu. ft.; 9⅞-in. at 100 rev., 141 cu. ft.; 11¾-in. at 80 rev., 247 cu. ft. It is quite right to state these data in cubic feet instead of by weight, but the speeds given are too high for good practice. However, the capacities appear to be stated moderately, notwithstanding. On the basis of material weighing 100 lbs. per cu. ft., the capacity of the 5⅞-in. screw would be 2.1 tons per hour; of the 7⅞-in. screw, 3.55 tons; of the 9⅞-in. screw, 7.05 tons; and of the 11¾-in. screw, 12.35 tons. The figures of either of these manufacturers seem to be on the safe side as to capacity, since a 9-in. conveyor run at 70 rev. per min. will certainly transport 10 tons per hour of ore weighing 150 lbs. per cu. ft., or 6⅔ tons of ore weighing 100 lbs. per cu. ft.

Ideas as to the power required to operate a screw-conveyor are less definite. In the transportation of any substance horizontally, friction is the only element which has to be overcome, not only the friction of the material itself but also that of the mechanism. It is evident, therefore, that the power required is a function of the weight of the material, the distance to which it is carried and the speed, plus the similar factors for the

mechanism. One manufacturer states that a 5⅞-in. screw run at 120 rev. per min. requires 0.5 h. p. per 33 ft. of length; a 7⅞-in. screw at 110 rev., 6.75 h. p.; and a 9⅞-in. screw at 100 rev., 1 h. p. These figures are rather lower than practice indicates, and would appear to correspond more closely to the power required to drive the conveyor empty than full. Another manufacturer gives the formula, $H.P. = WL \div 3 \times 33000$, in which W is the weight in pounds of the material to be carried per minute and L the distance in feet to which it is to be carried. According to this the power required to carry 10 tons of ore 100 ft. per hour would be only 0.33 h. p., which, of course, is absurd, since it would require far more power than that to run the conveyor empty. A 9-in. screw conveying that quantity of material would probably require 4 to 5 h. p. The formula should evidently be expressed as $H.P. = [WL \div (3 \times 33000)] + FL$, in which F stands for the power required to turn the screw itself at a specified speed. The screw is wasteful of power, because not only is the ore pushed through the trough as in the scraper conveyor, but also the screw presents a greatly increased frictional surface, while it is subject to all the frictional resistance of a poorly supported and carelessly attended line of shafting, running in grit all the time.

The screw-conveyor is the cheapest of all conveyors to install. A 9-in. screw, 100 ft. long, ought to be put up for about $300. On the other hand, all of its parts are subject to heavy wear, and repairs and renewals may easily amount to 100 per cent per annum, this depending upon the work required of it. There are some cases wherein it is advantageous to use a screw, notwithstanding its serious drawbacks. They are at their best when used for finely-crushed and dry ore. They are more troublesome with wet, clayey ores, and are quite unsuitable for coarse ores. A very long screw is apt to be a nuisance anyway. A short screw often makes a good feeding device. The screw-conveyor with externally heated trough has been proposed as a drying and roasting furnace. It has been used occasionally for the former purpose, but not for the latter. Neither arrangement commends itself.

Rotary-Conveyor. The screw-conveyor is often referred to as a spiral conveyor. Another form of spiral conveyor consists of a cylinder with an interior spiral, the cylinder being supported on rollers and revolving like a cylindrical roasting furnace. Conveyors of this form are seldom used. They would appear to be costly, clumsy and difficult to repair, while material can only be fed at one end and discharged at the other end, which in adaptability would make it the least advantageous of all conveyors. If the cylinder be set on an incline, or if it have a taper, of course no interior spiral is necessary. The cylindrical dryer and several forms of roasting furnaces are really forms of this type of conveyor, just as other mechanical drying and roasting furnaces embody the principle of the scraper conveyor. Roasting cylinders as long as 60 ft. are used in Europe, and cement kilns as long as 120 ft. are used in the United States.

Scraper-Conveyor. The scraper-conveyor consists essentially of a trough in which the ore is dragged forward by a series of transverse push-plates, called flights. The method of connecting the push-plates is subject to a large number of modifications. Thus there is the continuous cable, dragging circular flights through a V-shape or semi-cylindrical trough, and the monobar conveyor, in which the flights are carried by a series of single linked bars. One of the commonest forms of this type of conveyor is, however, the double link-belt chain, supported on rollers, wheels or sliding shoes, which run on rails at each side of the trough, carrying the flights between them. This is known as the suspended-flight conveyor. The chains pass over sprockets at each end of the conveyor and return on overhead rails. The sprockets at one end are keyed on the driving shaft, while those at the other end are carried in boxes which can be adjusted to take up the slack in the chains. The monobar conveyor can be constructed so as to make a bend in the horizontal plane, or even make the complete return circuit.

The scraper-conveyors have the advantage that they can be arranged to be fed or to discharge at any point. They have the disadvantages of involving a good many wearing parts and requiring considerable power to drive. The Link-Belt Engineering Company gives the following formula for power:

$$\text{H. P.} = (ATL + BWS) \div 1000,$$

in which A and B are constants depending on angle of inclination from the horizontal, T is the tons per hour to be conveyed, L the length of the conveyor in feet, center to center, W the weight in pounds of chains, flights, and shoes, and S the speed in feet per minute. For horizontal runs, $A = 0.343$ and $B = 0.01$. According to this formula, the power required to move 10 tons of ore per hour the distance of 100 ft. would be 3.5 h. p., but we should hesitate to reckon so low. Anyway, it always requires more power to start a conveyor than to operate it and therefore a larger motor should be provided. Scraper-conveyors are usually operated at speeds of about 100 ft. per minute. The weight of the chains, scrapers, wheels and axles or rollers, amounts to about 30 to 35 lbs. per foot, center to center, for a 10-in. or 12-in. suspended flight conveyor, which at 100 ft. travel per minute will have capacity for moving about 10 tons per hour of ore weighing 150 lbs. per cu. ft. The cost of a suspended flight conveyor 100 ft. long, installed, will come to about $450.

The capacity of a scraper-conveyor depends upon the width of the trough, the speed of the chain, the volume of the ore, and the frequency of the flights. The flights are commonly set 16 in., 18 in. or 24 in. apart. Obviously the flights will not push the ore ahead in an even sheet, but will crowd it up into little heaps, a succession of which will be moving through the trough. Therefore the more frequent are the flights, the greater the capacity of the conveyor. The suspended-flight conveyor is superior to other forms; it requires about 20 per cent less power than the

simple drag, runs more smoothly and is not so noisy. The point of special weakness in these conveyors is the chains, the breakage of which is likely to cause costly and vexatious delays. The monobar is better than the chains; the latter, if used, should be provided of greater strength than is frequently the case. The scraper-conveyor gives the best results with fine ore and moderate lengths. Many examples of large and long installations for the handling of lump ore, coal and rock are to be seen. They are very noisy and are subject to frequent breakdowns.

Reciprocating Conveyor. The reciprocating conveyor is a new modification of the scraper-conveyor, which is finding considerable favor. In this the ore is pushed forward in a trough by a series of flights which are hinged at regular intervals to a ladder-like frame, composed of a pair of channel beams joined by suitable cross-bars and mounted on rollers. This frame is given a reciprocating motion by a crank mechanism, which can be placed at any convenient point. In another form, the flights are fixed to a reciprocating rod, as an iron pipe of suitable strength, which is supported by wheels and axles. In either case, the flights are so hinged that in their forward motion they bear against stops, and push the material along, while in the backward motion they return to the starting point by dragging back over the top of the material. In this way the ore is literally shoveled forward stroke by stroke.

The reciprocating conveyor has these advantages: It can be fed and discharged at any point; it occupies less height than the chain scraper-conveyor; and all of its wearing parts, which anyway are comparatively few, are outside of the grit, save the flights themselves and the trough. On the other hand, it is uneconomical of power, owing to the frequency with which motion is reversed. At every stroke the inertia of the entire lot of ore in the trough has to be overcome and this will probably limit the usefulness of this type of conveyor to a comparatively moderate length. Moreover, they are obviously inapplicable to conveying materials containing lumps. They are considerably more costly than the ordinary scraper-conveyor, the cost varying according to the details of manufacture. Thus to install a reciprocating conveyor 100 ft. long, capable of transporting 10 tons per hour of ore weighing 150 lbs. per cu. ft., would cost from $700 to $1,200 (actual quotations, with an allowance for cost of installation). A 15-h. p. motor should be provided to drive. The capacity of this form of conveyor is determined by substantially the same factors as in the case of the scraper-conveyor.

Another form of reciprocating conveyor consists of a light trough, supported or suspended in a suitable manner, to which a to-and-fro movement is imparted by suitable mechanism. This form of conveyor is not in general use, but the writer has seen it employed with good success for transports of several hundred feet, the entire installation being of the simplest construction. Obviously, however, it is suitable only for fine, dry material, or else a loose pulp. In either case, the forward travel of the

material will depend upon the slope of the trough and the length and number of the jerks. The Wilfley conveyor, which is of this type, is used for the transport of wet concentrates, the motion of the trough being given by the same mechanism that is used for the Wilfley table. A patented reciprocating trough-conveyor has the bottom of the trough made in a serrated form, so that at each jerk the material goes over a ledge and therefore attains a positive forward movement.

Carrying Conveyors.

The conveyors of this type consist substantially of an endless belt, or a continuous chain of pans or buckets. There are numerous modifications of both forms.

Belt Conveyor. The belt conveyor is essentially a band supported on idlers and running over pulleys at either end, by one of which it is driven. A suitable arrangement at the other end serves to take up slack and keep the belt tight. The simplest conveyor of this type has a flat belt, which has to be quite wide in order to prevent material from spilling off. To obviate this, the belt is concaved, and to reduce the wear of the belt by being thus flexed it is manufactured in various ways. There is also a great variety in the composition of rubber employed and in the design of the supporting rollers. Rarely, a flat belt with side rims is run over plain rollers.

Irrespective of these modifications in design and construction, the belt conveyor is for many purposes the most efficient of all conveyors. It requires the least power to drive, save for the highly developed forms of continuous bucket conveyors; its first cost is moderate, and the expense for repairs and renewals is less than for any other form of approximately equal first cost. It is adapted to a great variety of uses, carrying ore up considerable inclines and at changes of angle, and has great capacity, but it has the drawback of inability to discharge at intervals, save by the use of a rather awkward and expensive tripper. It is possible, however, where electric power is available, to install a movable conveyor, run by a self-contained motor, and to cause the belt to discharge over the end into any one of a series of bins, by moving it forward or back; and the direction of the belt travel can be reversed. Thus, a line of bins 200 ft. long can be filled by a conveyor of a little more than half that length, the feed being received midway in the line of the bins. Similarly such self-contained conveyors can be constructed in portable form and used for work about the yard, such as the loading of railway cars. These are things which can not be done so conveniently with any other type of conveyor. Moreover, this can be used as a sorting belt at the same time as a carrying belt, and in taking ore to breakers and rolls a magnet can be set over the belt to pick out drill points and other undesirable pieces of steel and iron.

The rubber belt is quite durable and it may be reinforced on the wearing side by an extra layer of rubber, like elevator belts.

It is, however, unsuitable for carrying ore from dryers, etc., which is of such temperature as to affect the rubber. The limit of rubber belting in this respect is soon reached (it would be unsafe to attempt to carry ore so hot as 150° C.) but in such cases the Leviathan or Gandy belts may be substituted. Such cotton-duck belts are, however, less durable against abrasion than the rubber.

The capacity of a belt conveyor depends upon the width and speed of the belt and the weight of the material to be carried. If the belt is troughed it is safe to estimate that the load will cover one-half of the total width of the belt and that the depth in the center will be one-quarter of its own width. The cross-sectional area of the load (which may be considered as an inverted triangle) multiplied by 12 will give the number of cubic inches of material per running foot of length, and from the weight of the material and speed of the belt the capacity may easily be calculated, but an allowance must be made for irregularity in feeding. A flat belt will carry only about one-third as much as a troughed one.

A belt speed of about 300 ft. per min. is commonly used, but 450 ft. per min. is not excessive; belts have been observed to run smoothly at speed as high as 900 ft. per min., but the wear on both the belt and the idlers was then excessive.

A troughed 12-in. belt, run at 100 ft. per min., is able to carry 187.5 cu. ft. per hour, or 14 tons of ore weighing 150 lbs. per cu. ft., but to perform the duty that we have assumed for other conveyors in this article, viz., the transport of 10 tons per hour, we should install practically a 12-in. belt and run it at about 300 ft. per min. The cost of such a conveyor installed would be about $600 for a length of 100 ft. It would require about 3 to 3.5 h. p. to drive, assuming it to be properly installed. No general rule can be given for estimating the power required to drive a belt conveyor, which depends largely on the arrangement of the idlers. If they are too far apart the belt will sag down between them, increasing the load; if they are too near together the frictional resistance is increased. The greatest item of repairs in connection with a belt conveyor is the replacement of the belt, which is the most costly single piece of the apparatus. If the belt lasts five years the cost of repairs will come to about 12.5 per cent per annum; a belt life of only 2.5 years would mean a repair cost of about 20 per cent per annum. In a certain large works where a good many belt conveyors are employed the actual expense for repairs is not much more than 12.5 per cent per annum.

Continuous Bucket Conveyor. The pan and bucket conveyors consist essentially of an endless chain of overlapping pans and buckets, which may be arranged in a great variety of ways. One of the simplest is the endless traveling trough conveyor (referred to also as the open trough conveyor and apron conveyor), consisting of a series of overlapping sections of light sheet steel trough, which are secured on the under side of a heavy link-belt chain (or to a pair of chains); the chain passes over a sprocket

at each end of the conveyor and the pans are supported on rollers attached to the frame. These conveyors are considerably more expensive than the belt conveyors. The first cost of a 12-in. conveyor of this type, which would have capacity for 10 tons of ore per hour, would be in the neighborhood of $11 to $12 per foot, installed. Ordinarily they have the disadvantage of being able to discharge only at the end, where the pans pass over the tail sprocket (although in the forms wherein the pans are carried between a pair of chains, they can be arranged to dump at intermediate points by having a dip in the rails) and in this respect are of more limited application than the belt conveyors; but on the other hand they are suitable for conveying hot material or substances that would injure a belt. Conveyors of this type, of heavy construction, are used at various places for the transportation of hot slag and when properly installed give good service. It is only a little step further to the casting and conveying machines for pig iron and other metals.

CRUSHERS

Machines for crushing rock, ore and similar hard materials are in two usual forms. Jaw crushers and gyratory crushers. Jaw crushers are usually of smaller capacity than are gyratory crushers. The jaw crusher operates in general in the following manner:

An eccentric shaft in revolving imparts a backward and forward movement to a lever arm whose fulcrum is at the outside end. At a point between the power end of this arm and the fulcrum is a "toggle" to which is imparted a forward and backward movement by the arm and which in turn imparts the same movement to the lower end of a corrugated steel or cast iron crushing plate free at its lower and hinged at its upper end. Opposite this plate is a somewhat smaller fixed plate and the two together form the "jaws." By changing the toggle for a larger or smaller, the "set" or size of the opening at the bottom of the jaws is regulated, and thereby the size of the product. The "jaw opening" is the width by the length of the opening between the upper ends of the crushing plates and determines the greatest size of stone that can be introduced.

The jaw crusher is of limited capacity, its product is not uniform, and the machine itself is subject to frequent breakages due to the severe shocks it has to sustain. For these reasons the gyratory crusher was invented and is used wherever a uniform product of great quantity is essential. The principal objection to it is its non-portability. In this type of crusher a perpendicular shaft, to which are fastened the inner crushing plates, revolves with an eccentric motion, inside of the stationary outer crushing plates. The actions of the inner jaw plates are both rolling and crushing. The horizontal distance apart of the lower ends of the concentric jaws determines the size of the product and is regulated by raising or lowering the inner jaw.

JAW CRUSHERS

CLIMAX ROCK CRUSHERS

TABLE 91

Opening (Ins.)	Capacity, Tons per Hour	Weight, Not Mounted (Lbs.)	Price
7 x13	Small	.....	$ 425
8 x15	10 to 15	5,000	465
9 x16	12 to 18	7,000	570
10 x20	15 to 25	9,250	780
10½x22	15 to 30	15,500	860
12 x28	25 to 40	27,000	1,300
14 x28	50		1,430

CHAMPION ROCK CRUSHERS

TABLE 92

Jaw Type

Opening (Ins.)	Capacity, Tons per Hour	Weight, Not Mounted (Lbs.)	Price
7x13	8 to 12	5,500	$ 425
9x15	12 to 18	8,800	465
10x20	16 to 24	12,500	780
11x22	18 to 26	15,000	880
11x26	24 to 35	20,000	1,260
14x26	....	......	1,400
11x26	....	Heavy	2,620

The following are prices of crushers made in the middle west:

TABLE 93

No.	Jaw Opening, Inches	Capacity Per Hour, Tons	Approx. Weight, Lbs.	Speed	H. P. Req.	Price
8	8x16	10 to 15	7,500	300	12	$ 520
9	9x18	10 to 20	8,500	300	15	620
10	10x22	16 to 25	11,500	280	20	865
11	11x26	24 to 30	13,500	275	25	1,170

Crusher complete, mounted on trucks with heavy steel axles, and steel or wooden wheels, having an output of 15 to 30 tons per hour when the jaw (11"x18") is set at an opening of two inches (weight 10,100 lbs.) with an elevator 14 ft. long with folding device (weight 1,200 lbs.) and a screen, of the chute type of steel rods or perforated metal, costs $1,120. An 18 horsepower engine is necessary to operate it.

The dimensions, weights, capacities, required power and prices of some of the smaller sizes of rock and ore breakers are here given:

Dimensions of each Receiving Opening About (Ins.)	Weight of Breaker (Lbs.)	Capacity per Hour, According to Character of Rock or Ore, in Tons of 2,000 Pounds, to Pass Through a Ring of						Smallest Sizes of Product of Machine (Ins.)	Dimensions of Driving Pulley (Ins.)	Revolutions of Driving Pulley	Horse Power Required	Price, f.o.b. works
		1½	1¾	2	2½	3	3½					
8x30	22,000	15	20	25	30	40	..	1½	32x12	400	14 to 21	$1,180
10x38	32,800	..	30	40	50	60	70	1¾	36x14	375	22 to 30	1,550
12x44	48,000	..	..	50	70	80	90	2	40x16	350	28 to 45	2,030

Equipment suitable for use with the above crushers is as follows: Screens: One 32"x10' iron frame screen complete. Revolutions driving pulley, 55; size driving pulley, 42x8½; approximate horsepower, 6; weight, 5,900 lbs.; price $490; one 40"x14' iron frame screen complete. Revolutions driving pulley, 45; size pulley, 54"x11½"; approximate horsepower, 10; weight, 9,250 pounds; price, $590.

ELEVATORS

	Buckets Size	Buckets Gauge	Weight, Lbs.	Price
With geared head, 50′ centers........	13x10	No. 14	4,650	$490
With geared head, 50′ centers........	16x11	No. 14	5,835	585

"Back Gear Driving Connection" is an arrangement for driving the elevator and screen, particularly used with the smaller sizes, and takes power from the breaker.

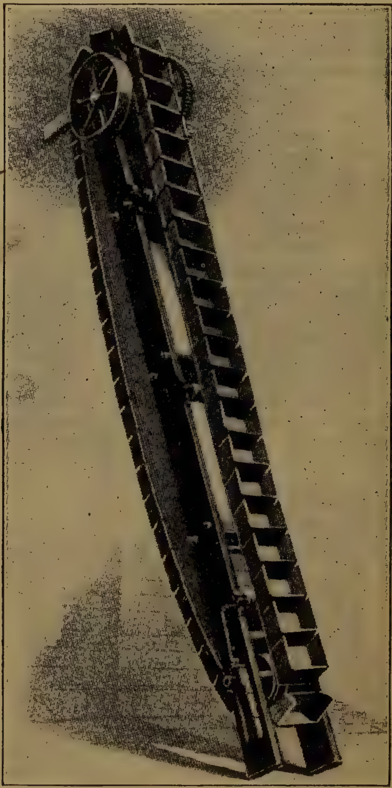

Fig. 74. Geared Elevator, Left-Hand Driven.

Countershaft. The cost of the iron work for one of these is about $50.

Breakers suitable for general contracting use have the following capacities:

Dimensions of each receiving opening about (Ins.)	Dimensions of receiving openings combined about (Ins.)	Weight of Breaker (Lbs.)	Capacity per hour, according to character of rock or ore, in tons of 2,000 lbs., with machine set for 2½-in. to 5-in. ring	Smallest sized product that can be made at one break (Ins.)	Dimensions of driving pulley Diam.	Face Inches	Revolutions of driving pulley	Horse power required	Price, f. o. b. works
6x21	6x42	8,400	6 to 12	1⅛	24	8	450	7 to 12	$600
7x22	7x45	14,480	10 to 20	1⅜	28	10	425	10 to 16	$800

Equipment for above costs as follows:

One 32x14 iron frame screen	$420
One No. 3 elevator, 50′ centers	445
One No. 3 back gear drive (iron work only)	40

Mounted crushers (small size only) cost about $350 extra.

A portable crushing and screening plant consisting of 10x18 crusher, 17 ft. folding elevator, 30 inch by 9 ft. revolving screen and a 15-ton portable bin costs $1,575 complete. This plant with a 9x16 crusher costs $1,385 and a 20 horsepower traction engine is necessary to operate it.

The following is the estimated cost of a complete portable crusher and plant for macadam road building.

1	crusher, 9x15″, with rotary screen	$1,000.00
	Portable bins	200.00
1	15-H. P. engine	200.00
1	20-H. P. boiler	600.00
12	wheel scrapers	500.00
12	drag scrapers, shovels and picks	100.00
2	graders	100.00
2	steam drills	500.00
1	15-H. P. boiler for drills	400.00
	Water and steam pipes, quarry tools. etc	300.00
1	sprinkling wagon	500.00
1	10-ton steam roller	2,500.00
	Total	$6.900.00

ROTARY CRUSHER

No.	Hopper Opening	Approx. Cap. Tons per Hour	Approx. H.P.	Speed Rev.	Pulley Diam. Face	Length	Width	Height	Approx. Weight Lbs., Net	Approx. Weight Lbs., Gross
1	13x18	1 to 6	6 to 10	300	24x 8	6′7″	3′ 2″	2′	4,000	4,700
2	18x28	8 to 15	15 to 20	250	30x12	8′8″	3′10″	7′2½″	9,000	10,500
3	26x35	15 to 35	25 to 30	250	36x16	10′0″	5′ 3″	10′5 ″	20,000	22,000

Prices: No. 1, $360; No. 2, $810; No. 3, $1,810.

The cost of moving a 9x15 crusher plant with non-portable bin a few miles and setting up ready for crushing is about $75 under average conditions.

Repairs. In crushing 224,203 tons of rock in 1886-7 an average of eight sets of crusher apparatus being in operation, the following new parts were required.

12 levers	@	$25.00	$300.00
9 jaw plates	@	15.50	139.50
12 jaw plates	@	12.00	144.00
Toggles, check plates and sundries			247.80
Total			$831.30

or an average of about $100 per crusher. This does not include babbitting the bearing or labor of making repairs.

Repairs for Rolls.

7 pairs tires	@	$120	$ 840.00
Gear wheels and pinions			335.00
Total			$1,175.00

or about $147 for each pair of rolls. The tires of the rolls used for coarse crushing are not turned when worn, but are replaced by new ones. For the screens 21 sets of perforated plates @ $60.75 = $1,275.75 were required, or an average of 2.6 sets per year per screen. The average life of the wearing parts of a jaw crusher is therefore about eight months; a set of screen plates about four months.

In Camp's "Notes on Track" there is a description of a crushing plant installed by the Pennsylvania railroad for the crushing of track ballast. It consisted of a gyratory crusher of 40 to 50 cubic yards per hour capacity and a smaller auxiliary crusher. The stone from a large crusher was taken by a belt conveyor to a revolving plate screen 12 feet long by 4½ feet in diameter, divided into three sections having one-inch, two-inch, three-inch holes. On the outside of the one-inch hole screen was an auxiliary screen of ½-inch mesh. The rejected material was led through a chute to the smaller crusher whence it was again conveyed to the screens. After the stone had been screened it dropped into four bins. The products of the stone were 17 per cent screenings, 8 per cent ¾-inch stone, 33 per cent 1½-inch stone, 42 per cent 2½-inch stone. From the bins the material was chuted directly into cars. This plant was operated by a 150-horsepower engine. The labor necessary consisted of one fireman, one oiler and four laborers whose total wages per hour were $1.19½. The repairs and renewal of broken parts cost $500 for four hundred working hours.

The Dolese & Shepard Company of Chicago have estimated the life of their new stone crushing plant at twenty years with 5 per cent annual depreciation. They have found from experience that repairs to crushers cost 5 per cent annually, repairs to screens and conveyors 15 per cent. The large size stone wears

the screens and conveyors much more rapidly than the small size stone. For example, the screen for No. 9 crushers had to be renewed in nine months, whereas the other screens had been in service eight months and showed no wear.

The Illinois Stone Company, at Lemont, Ill., has a stone-crushing plant with a capacity of 700 cu. yds. in 10 hours. The plant is a timber structure and cars are hauled up a short incline to the main crusher where they are dumped automatically. The stone passes through a No. 7½ and two No. 4½ gyratory crushers, and 3-ft. cylindrical screens of sizes from ⅜ in. to ½ in. The original cost of the machinery, the three crushers, screen, belts, etc., was $23,000. The cost of repairs given below is for new parts and does not include the labor of making repairs.

First Year	$1,900.00
Second Year	600.00
Third, Fourth and Fifth Years	1,400.00
Total for Five Years	$3,900.00
Average per Year	$780.00

The ¼ in. steel plates have been replaced about twice a year.

DISC CRUSHER

A third type of crusher is of the disc pattern (see Fig. 75). This was not employed in ordinary hard rock work until 1909, but is now coming into use. It is especially useful for crush-

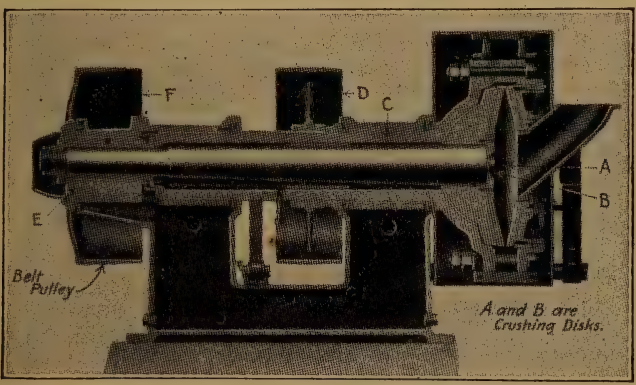

Fig. 75. Symons Disc Crusher.

ing the tailings of gyratory crushers and for breaking gravel or boulders. It can be quickly adjusted to crush any size of product between $\frac{5}{16}$ in. and 3 in.

The crushing is done by the two discs of manganese steel, which are dish-shaped and are set with their hollow sides facing each other, and at an inclination towards each other. Both discs rotate in the same direction at the same speed. When the stone

is fed through a central feed opening it is thrown by centrifugal force into that part of the hollow where the discs are wide apart. It is then carried around with them to where they are close together and is thereby crushed. The small pieces fly out from between the discs while the large particles are caught again and the operation repeated.

TABLE OF SIZES AND WEIGHTS

Size of Crusher	Approx. Shipping Wt. Lbs.	H. P. Required	Min. Exit Opening for Best Results	Price
48″	30,000	50 to 65	1 ″	$3,000
36″	19,000	30 to 40	¾″	2,150
24″	8,500	18 to 25	½″	1,250
18″	5,600	12 to 18	⅜″	950
13″	3,000	10 to 15	¼″	600

LISTED CAPACITY IN TONS PER HOUR

Size Crusher	Size Ring	Tons per Hour	Size Crusher	Size Ring	Tons per Hour
48″	1	45 to 70	24″	1½	25 to 30
48″	2½	85 to 100	18″	⅜	5 to 8
36″	¾	25 to 30	18″	1	12 to 15
36″	2	50 to 60	13″	¼	4 to 5
24″	½	12 to 15	13″	¾	8 to 10

ESTIMATED COST OF QUARRY PLANT, GABBRO

The following estimated cost of constructing and operating a quarry plant suitable for manufacturing ballast for railroads, is obtained from the Proceedings of the American Railway Engineering and Maintenance of Way Association, 1909.

Cost of Plant. From published figures, the cost of building a plant of 1,000 tons daily capacity, and its cost of operation to quarry, is as follows:

Capacity, 1,000 tons daily	300,000 tons annually
900 cu. yds. trap per 10 hour day	270,000 cu. yds. annually
Crushers, 4, 250-ton Farrell, at $1,250	$ 5,000
Engines, 4, 60 H. P., 14x12 at $500	2,000
Foundations	100
Belting, 13″, 200 ft. at $2.75	550
Boilers, 2, 200 H. P. and setting	7,500
Steam fittings	4,000
Boiler house	2,500
Engine house	1,500
Stack	2,000
Scales, 60 ft., including foundations and timber	1,225
Bins	600
Elevators with platforms, 4 at $1,500 (for tailings)	6,000
Pump for water supply, 5,500 gallons per hour	200
Tank, 50,000 gallons	1,200
Steam drills with tripods connecting hose, 20 at $245	4,900
Screens, rotary, 54″, 4 at $950	3,800
Small tools, forges, bars, wedges, hammers etc.	1,200
Derrick, small stiff leg	150
Total	$ 44,425
Contingencies, 8 per cent	3,553
	$ 47,978
Land, 50 acres at $150 per acre	7,500
Cable railway and dump cars for haul to crusher, this being a varying item as quarry is worked	5,000
Total cost of quarry	$ 60,478

COST OF OPERATION OF QUARRY PLANT, GABBRO

18 drillers at $3 per day, 300 days	$ 16,200
18 helpers at $1.75 per day, 300 days	9,450
3 blacksmiths at $3 per day, 300 days	2,700
50 bar-sledgers at $1.75 per day, 300 days	26,250
60 coal loaders at $1.75 per day, 300 days	31,500
8 crusher men at $1.75 per day, 300 days	4,200
1 quarry boss at $5 per day, 300 days	1,500
1 fireman at $2.50 per day, 300 days	750
1 engineer at $3 per day, 300 days	900
4 bin men at $1.75 per day, 300 days	2,100
1 scale man at $2 per day, 300 days	600
1 carpenter at $3 per day, 300 days	900
10 laborers at $1.75 per day, 300 days	5,250
1 clerk at $750 per year	750
Fuel, 2,700 tons of coal at $2.70	7,290
Oil waste, etc.	500
Dynamite, 7 lbs. per cu. yd.; 270,000 cu. yds.—189,000 lbs. at 15c	28,350
Drill repairs, 1 machinist at $4	1,200
1 helper at $2.50	750
Supplies at $1.25 per month per drill	270
Blacksmiths included above	...
Total	$141,410

4 per cent on first cost of plant	$2,418	
10 per cent depreciation on machinery, except crushers	2,160	
16⅔ per cent depreciation on crushers	833	5,411
		$146,821
Contingencies, 8 per cent		11,750
		$158,571

This shows a cost per yard of 59 cents.

Outputs of Stone Crushers. Very little has appeared in print regarding the outputs of stone crushers, and accordingly the accompanying table showing the actual output of a number of stone crushers may be of interest:

	(1) Austin, in.	(2) No. 9 Gates—No. 6 Austin	(3) No. 5 Austin—No. 3 Gates	(4) No. 3 Austin
Size of crusher	7½	...	...	..
Size of broken stone, inches	2½	2½, 1½, 1½ and screenings	2½	2†
Number of men feeding crusher	2	1	2	2
Output in cu. yds. per 100 hours	300	600	360	80 to 120
Aver. output in cu. yds. per 10 hrs.	300	600	450*	..
Best output in cu. yds. per 10 hours	450	750	500*	..

* Tons. † Nothing larger than will pass a 2 in. screen.

(1) Information furnished by the Breckenridge Stone Co., Breckenridge, Minn. The rock was a limestone. In addition to the two men feeding the crusher, about 45 others were employed by the company on other work about the crusher and quarry. (2) Information furnished by the Lake Shore Stone Co., of Belgium, Wis. The rock was a very hard dolomite limestone. The "one man" referred to in the table keeps the stone from "bridging" and keeps the hopper free. In addition, 44 men were employed loading stone into cars going to the crushers. (3) Information furnished by the Elk Cement & Lime Co., Petoskey, Mich. The crushers were side by side, the Gates being used for rejections. The rock was a hard limestone. The size of broken stone from the crusher ran up to 2½ in. (4) Information furnished by Holmes & Kunneke, Columbus, O. The rock was a hard limestone.

COST OF OPERATING A STONE CRUSHING PLANT BY CITY EMPLOYEES FOR THREE AND ONE-HALF MONTHS, BOSTON, MASS.

The Boston Finance Commission, in 1908, made a statement to the effect that in 12 years the city of Boston had wasted $1,000,000 by operating its own stone crushing plants instead of buying crushed stone from contractors for street work. Upon the request of certain city employees who professed confidence in their ability to turn this tide of extravagance, the mayor promised that for a limited time one crushing plant would be placed at their disposal to demonstrate their claims. The employees chose for the experiment the Church Hill Ave. plant and the Boston Finance Commission placed the work of recording the results in the hands of its engineers, Metcalf & Eddy, of Boston. The full report of the engineers is given in Vol. III. of

Finance Commission's report recently made public and from this I take the following data:

The crusher plant occupies an area of 570,000 sq. ft., purchased in 1882 for $30,000 and having an assessed value in 1907 of $79,800. The tract is used in part for other than quarrying and crushing purposes. The plant consists mainly of a 30x13-in. Farrel crusher, a 72x16-in. Atlas engine, a 66-in. x 17-ft. tubular boiler, the usual elevators, bins, extra parts and tools, and of three large and one baby steam drills. The estimated cost of the plant was $16,653; interest was calculated at 4 per cent and depreciation at 6.75 per cent annually, which gives an amount of $1,791 which in the costs following was applied on a monthly basis. The charge for steam drills is based on a rental of 50 cts. per working day.

Force Employed. The force employed, with wages, was in general as follows:

	Per Day
Labor at Ledge:	
1 sub-foreman at $3.50	$ 3.50
1 blacksmith at $3	3.00
1 blacksmith's helper at $2.25	2.25
3 steam drillers at $2.25	6.75
3 steam drillers' helpers at $2.25	6.75
10 stone breakers at $2.25	22.50
5 hand drillers at $2.25	11.25
1 powderman at $2.25	2.25
9 loaders at $2.25	20.25
Total	$ 78.50
Labor at Crusher:	
1 engineer at $3.50	$ 3.50
1 fireman at $3.25	3.25
1 weigher at $3.50	3.50
1 oiler at $2.25	2.25
3 feeders at $2.25	6.75
1 pitman at $2.25	2.25
Total	$ 21.50
Teaming:	
6 single teams at $3.50	$ 21.00
Total	$121.00

The force consisted largely of men who were in some degree skilled in rock work. The majority of the men were young and all were vigorous and skilled to such an extent that the force as a whole was skillful and efficient. There was a marked lack of interest on the part of some of the employees, which undoubtedly had its effect in reducing the amount of work done considerably below the amount which would be done under contract conditions; on the other hand, it should be stated that some of the men took a lively interest in the work and did their full duty.

Preparatory Work. To put the plant in condition for the test there were expended the following amounts:

Items	Cost
Labor	$207.51
Teaming	7.50
Materials	38.34
Total	$253.35

This made a charge of $0.028 per ton of output during the test run. There were also $68.44 expended on repairs to scales which, being permanent repairs, were not charged to the test; they amount to a charge of $0.0076 or about ¾ ct. per ton of output. To house and prepare plant and tools for the winter after the conclusion of the test run cost $18 or $0.002 per ton of output.

Method of Operation. The quarry was first stripped of the earth overlying the ledge, after which holes were drilled in the rock by means of steam drills. These holes were loaded with dynamite and exploded, thus throwing out great quantities of stone. Much of the stone thus thrown out was in large blocks, which required breaking before they could be put into the crusher. In some cases this could be done by sledging and in other cases holes were drilled in them by means of a baby steam drill and hand drills, and the blocks cracked by use of dynamite. The stone thus prepared for the crusher was hauled to the loading platform, where it was dumped into the crusher and upon the platform. Men were stationed on the platform to feed the rock into the crusher. After passing through the crusher the broken stone was delivered by elevator to a revolving screen where it was separated into two grades; the very fine, or dust, being conveyed to one set of bins and the cracked stone to another set. These bins hold approximately 400 tons; and when the demand for stone for use upon the streets was not equal to the output of the crusher, and the bins were full, it became necessary to haul the balance of the output to a pile in the yard—about 2,259 tons of broken stone and 194 tons of dust being stored in the yard for this reason.

There was a misunderstanding with regard to hauling of stone from the bins to the pile in the yard, which caused a slight delay on July 1, 2 and 3, during a portion of which time the crusher was shut down. This delay amounted in the aggregate to not over two days of crusher service, during which time the quarrying was proceeding as usual. After July 3 there was no appreciable delay on account of causes beyond the control of the foreman, except such occasional delays as are inevitable upon such work due to temporary disablement of the plant.

In this connection it should be noted that the capacity of the bins being only about 400 tons, they were sufficient only for about 2½ days output of the crusher as it was operated. The normal capacity of the crusher is claimed by the manufacturers to be about 250 tons per day, while the maximum output for any one day during this test was 225 tons.

During three weeks in July, three drills were operated, but this was found to be inadvisable because the force of laborers was unable to handle the rock as fast as it was blown out.

Periods of Operation. The results of this test have been divided into three periods, so that the comparative progress from time to time can be noted, as well as any improvement in the cost of operation. The dates of closing these periods were so selected that the amount of uncrushed stone which had been

quarried was comparatively small, being in no case in excess of 200 tons.

First Period—The first period was from May 28 to July 13, inclusive, but included only that drilling and blacksmithing done up to July 6, inclusive, which corresponded to the output of the first period. The work and expense of this period may be summarized as follows:

Work Done:

Stripping removed	174 tons
Holes drilled (2¾-in. diameter) by steam drills	1,069.5 ft.
Unbroken stone on hand at expiration of period (estimated)	200 tons
Broken stone ready for crusher at end of period	none
Total output of crushed stone during this period	1,651 tons

Cost:

Labor and teaming per ton of output	$1.21
Materials used per ton of output	0.11
Total cost per ton of output	$1.32

In this summary, as in the summaries of the other periods, no account is taken of interest, depreciation or rental of plant, and certain general items of expense, or a few incidental supplies. The final summary covering the entire period, however, includes all of these expenses.

It should be noted, in the consideration of the first period, that the cost per ton of output includes all of the preliminary work, which amounted to approximately $0.15 per ton of the output of this period. Deducting the cost of the preliminary work from the cost per ton of output, $1.32, for the first period leaves the net cost for this period $1.17 per ton, which cost can be compared with similar costs for the second and third periods.

Second Period—The second period extended from July 14 to 11 a. m. of July 21, inclusive, and includes the drilling and blacksmithing applicable to this period. The work and expense of the second period may be summarized as follows:

Work Done:

Stripping removed	85 tons
Holes drilled (2¾-in. diameter) by steam drills	402.7 ft.
Unbroken stone on hand at expiration of period (estimated)	50 tons
Broken stone ready for crusher at expiration of period	none
Total output of crushed stone during this period	906 tons

Cost:

Labor and teaming per ton of output	$0.80
Materials used	0.08
Total cost per ton of output	$0.88

Third Period—The third period extended from 11 a. m. of July 21 to September 10, inclusive, and final date of the test. The work and expense of the third period may be summarized as follows:

Work Done:

Stripping removed	125 tons
Holes drilled (2¾-in. diameter) by steam drills	2,087.9 ft.
Unbroken stone on hand at expiration of period (estimated)	200 tons
Broken stone ready for crusher at expiration of period	none
Total output of crushed stone during this period	6,397 tons

Cost:

Labor and teaming per ton of output	$0.76
Materials used	0.08
Total cost per ton of output	$0.84

It should be noted that the cost per ton of output during the third period was very close to that of the second period. The reduction in cost of stone crushed during the second and third periods below that of the first period, after deducting the cost of preparatory work, shows the result of the experience acquired by the force and improvement in organization.

Results of Entire Test. As already stated, the duration of this test was from May 28 to September 10, inclusive. The details of the cost of this test are given in Table B. The work accomplished during the test may be summarized as follows:

Work Done:

Stripping removed (a large part of the stripping had been done prior to the beginning of this test and is not included herein)	384 tons
Holes drilled (2¾-in. diameter) by steam drill	4,160.1 ft.
Unbroken stone on hand at beginning of test	none
Unbroken stone on hand at expiration of test (estimated)	200 tons
Broken stone ready for crusher at expiration of test.	none
Broken stone on hand at expiration of test	none

Total output of crushed stone during test:

Dust	1,970 tons (22 per cent)	
Stone	6,983 tons (78 per cent)	
Total		8,953 tons

The cost to the city of producing the 8,953 tons of crushed stone, exclusive of $68.44 paid for permanent repairs to the scales, may be summarized as follows:

Cost:	Per Ton
Labor and teaming	$0.881
Material used	0.106
Interest, depreciation and rental of tools and machinery	0.069
Estimated equivalent cost of stripping done prior to beginning of test	0.025
Total cost	$1.081
Less cost of quarrying 200 tons of unbroken stone remaining at expiration of test	0.006
Net cost of crushed stone produced	$1.075

The major items of the foregoing summary may be subdivided into a comparatively small number of items which will show the cost of the various parts of the process of preparing crushed stone. (See Table A.)

TABLE A—SUMMARY SHOWING APPROXIMATE DISTRIBUTION OF EXPENSES AT CHESTNUT HILL AVENUE CRUSHER

	Cost	Cost per ton figured on output*	Per cent of total charged to output
Quarrying and breaking ($50 having been deducted on account of unbroken rock remaining at the end of test)	$4,263.27	$0.476	44.3
Stripping	244.54	.027	2.5
Stripping done prior to test (estimated)	223.83	.025	2.3
Loading and delivery to crusher	1,980.99	.221	20.5
Crushing:			
Operation (including feeding crusher)	1,255.89	.140	13.0
Interest and depreciation on plant (3 months at $149.25 per month)	447.75	.050	4.7
Special expenses:			
Weighing stone	181.57	.020	1.9
Weighing stripping	19.67	.002	0.2
Hauling bins to pile (2,453 tons)	281.15	.032	3.0
Holidays	705.75	.079	7.3
Absent with pay	27.58	.003	0.3
Total charged to output	$9,631.99	$1.075	100.0
Permanent repairs to scales	68.44		
Total cost of test	$9,700.43		

* Output equals 8,953 tons of crushed stone (including dust). These units may be grouped as follows:

Quarrying and breaking	$0.749
Crushing	0.244
Holidays and absent with pay	0.082
Total	$1.075

Distribution of Cost of Foreman, Engineer, Fireman and Coal. The foreman devoted his time almost wholly to the work of quarrying and breaking the rock for the crusher, and only a small portion to the operation of the crusher. We have, therefore, charged 30 per cent of his time to the quarrying, 60 per cent to the breaking and 10 per cent to the crushing.

The steam for running the steam drills was furnished from the boiler, which constituted a part of the crusher plant. This boiler was under the general direction of the engineer and was cared for by a fireman. We have not charged any portion of the time of the engineer to quarrying, but have charged one-half of the time of the fireman as well as one-half the cost of the coal used.

Stripping. In certain places the ledge was covered with a layer of earth, which it was necessary either to remove before blasting or separate from the stones after blasting. A portion of this material had been removed from the ledge prior to the beginning of this test. The quantity of stripping removed dur-

ing the experimental run was 384 tons, and our estimate of the amount which was moved prior to the beginning of the run (the cost of which should be charged against this experiment) would be 350 tons, or an amount nearly equal to that removed during the test. The cost of stripping done during the test was $0.637 per ton of soil stripped from the surface of the ledge. At this rate, the stripping done prior to the test would have cost $222.95 had it been done by the same force as a part of the experiment. This estimated cost of preliminary stripping amounts to $0.025 per ton of output.

Allowance for Rock Quarried but Not Blasted. As already stated there was no quarried rock on hand at the beginning of the test, but there was a quantity of about 200 tons remaining at its close. This should, of course, be credited to the experiment, which has been done by deducting the cost of quarrying it from the entire cost of the experiment. The cost of quarrying, including stripping, was about $0.25 per ton of rock quarried (8,953 tons of output + 200 tons unbroken rock = 9,153 tons quarried). The cost of quarrying 200 tons was therefore $50, which amounts to $0.005 per ton of output, which has been deducted from the total cost of output.

Resumé of Results of Test. This test has covered a period of time sufficiently great to demonstrate with accuracy the cost of producing crushed stone at the Chestnut Hill avenue crusher by day labor, under the conditions of the test. The force apparently consisted of men skillful and competent as could be selected from the entire organization of the division, and certainly gave evidence of being reasonably skillful and able-bodied. So far as could be seen the foreman in charge of the work was given an absolutely free hand to organize his force as he deemed best, and to adopt such methods of handling the work as he might desire. With very slight and unimportant exceptions he was furnished with tools and supplies promptly, so that there is no reason to think that the output could have been increased by the improvement of conditions depending upon the co-operation of his superior officers in the Street Department. The net result of this test appears to be that the crushed stone was produced at a cost to the city of $1.075 per ton. These figures make no allowance for the cost of the quarry to the city, or the cost of administration and clerical services at the office, the latter of which is estimated at $0.05 per ton of output.

This experiment has been carried out under the very best of conditions. The quarry and crusher selected was the most favorable of any which the city has worked in the past, and produced crushed stone in 1905 more cheaply than any other crusher. During that year each of five crushers produced more than 30,000 tons of broken stone—the Bleiler, Centre Street, Chestnut Hill Avenue, Codman Street and Columbia Road crushers. Of these the Chestnut Hill Avenue crusher yielded the smallest output, although the cost per ton of crushed stone, $1.148 was lower than that of any of the others. The cost of producing crushed stone during the test was therefore reduced less than $0.08 below

the cost of producing crushed stone at this crusher during the year 1905.

We have already called attention to the marked increase in efficiency of the force employed at the crusher during the second and third periods of the experiment. It is reasonable to inquire what the cost of the output would have been had all the work been done with the same efficiency. Such an estimate may be obtained by adding the cost of interest and depreciation, rental of machinery and tools, temporary repairs, and the stripping done before the beginning of the test, to the cost of any particular period, or an assumed cost. These items amount to over $0.10 per ton of output, so that it is reasonable to estimate the cost of operating the crusher at $0.95 to $1 per ton of output, based upon the efficiency attained during the second and third periods. This estimate, as in all other cases, does not include any charge on account of administration or office expense, nor does it include any charge for the cost of owning and maintaining the quarry.

Comparison with Market Prices of Crushed Stone. According to the report upon stone crushers already cited, the market price of crushed stone f. o. b. cars at the crusher is 50 cts. per net ton. While it is not possible to determine accurately the market price of crushed stone f. o. b. cars Boston, under a contract similar to one which the city might negotiate, an estimate was given in the report, from which we have just quoted, amounting to $1 per ton f. o. b. cars, or $1.10 loaded upon wagons ready for hauling to the streets. It thus appears that the cost of crushed stone produced during this test was more than twice that of crushed stone f. o. b. cars at the crusher of a private corporation, or more than twice the price for which it could be produced at the Chestnut Hill Avenue crusher by a contractor, and that the cost was about $0.025 less than the estimated contract price of crushed stone purchased in the local market and loaded upon wagons in Boston. These figures include no part of administration or office expenses, and no portion of the cost to the city of owning and maintaining the quarry. The administration and office expense would doubtless amount to as much as $0.05 per ton of output, but we are not in position to make any estimate of the cost to the city of owning and maintaining the quarry.

We made the statement that the cost of crushed stone produced during the test was more than twice the price for which it could be produced at the Chestnut Hill Avenue crusher by contract, upon the assumption that conditions could be the same at this crusher as at the large commercial crushers in use.

As we understand the law, a contractor producing stone at this crusher for the use of the city would be obliged to confine the hours of labor to an eight-hour day, which would materially increase the cost of his work. It is also probable that the city would find it impracticable to take the maximum output of the crusher at all times, which would also be an important factor in the cost of operating this plant.

As stated in our report, the companies furnishing crushed stone within reasonable railroad distances of Boston appear to be very

willing to dispose of their product at 50 cents per ton f. o. b. cars at crusher. We have one instance where crushed stone of one size (not the run of the crusher) was furnished at a cost of 55 cents per yard, or about 44 cents per ton delivered in place, including more or less freight expense. Obviously this stone was sold at a price at least as low as 40 cents per ton at crusher. It should be borne in mind, however, that these plants are very large ones, much larger than the Chestnut Hill Avenue crusher.

We have obtained the following data relating to the cost of operating a small temporary crushing plant on a trap rock quarry from April to October, 1906. The crusher was a 10½ by 18 inch Acme—a smaller outfit than that in use at Chestnut Hill Avenue. The cost of producing the stone is given in detail in the following table:

	Cost	Cost per Ton
Picking or drilling	$1,165.08	$0.0628
Breaking	1,937.23	.1042
Loading	1,843.99	.0994
Hauling	800.00	.0432
Crushing	1,229.73	.0662
Superintendence	437.10	.0235
Coal, oil, etc.	520.00	.0280
Dynamite and exploders	416.00	.0224
Total	$8,349.13	$0.4497
Plant rental ($210 per mo.)		.0792
		$0.5289

It appears from the foregoing table that the total amount of stone, 18,559 tons, was quarried and crushed for 45 cts. per ton, not including rental of plant. The rental of plant—actually a rented plant—was $0.0792, which added to 45 cents would make a total cost of 53 cents per ton.

It is important to note that during the test run of the Chestnut Hill Avenue crusher, the average output was 120 tons per day for three months (75 days) of actual operation of crusher. The nominal capacity of the crusher being 240 tons, it appears that the output was just one-half of the capacity. Under good management there should be no difficulty in turning out 240 tons of stone per day, and this could have been turned out during the test run without materially increasing the expense of the output, except for the cost of quarrying and breaking. These items would have been materially increased if the methods, discipline and character of labor remained the same.

In considering this subject, it should be borne in mind that there is not sufficient rock available at this location to warrant the establishment of a very large crushing plant. There is probably stone enough to supply the present crushing plant for a period of three or four years. (This is only a rough guess because no measurements have been taken upon which to base an opinion.)

From a further consideration of the statement in our report, which we have quoted above, we are of the opinion that a contractor might produce crushed stone at the Chestnut Hill Avenue

crusher for about one-half of the cost of crushing stone during the test run. This, however, would probably not include the contractor's profit, and would necessitate his having an abundant market which would enable him to work the plant to its maximum capacity. It is not probable that the city could let this work to a contractor for a sum as low as one-half the cost of the output during the test run for the reasons already given.

Cost of Hauling Crushed Stone to the Streets. An examination of the teaming checks covering a period of about three weeks, a portion of which was during and a portion after this test, showed that the cost of delivering stone amounted to about $0.40 per ton for the first mile, and about $0.10 per ton for each additional mile. Thus, with stone costing $1.075 per ton in the bin, the total cost to the city of such stone delivered to the street, at a distance of one mile from the crusher, would be $1.475 per ton, or at a point two miles from the crusher, $1.575 per ton. For comparison with contract prices, this figure should be increased by the amount of the cost of purchasing and maintaining the quarry and the proportionate cost of administration and office forces, not only on account of the quarrying and crushing, but also on account of teaming.

TABLE B—DATA ON COST OF OPERATING STONE CRUSHER AT CHESTNUT HILL AVENUE LEDGE, BRIGHTON, MASS., FROM MAY 28 TO SEPTEMBER 10, 1908, INCLUSIVE

Item	Total cost	Cost per ton figured on output
Labor:		
Supervision (foreman):		
Quarrying and breaking 90 per cent	$ 253.58	$0.028
Crushing, 10 per cent	28.17	0.003
Buildings	93.36	0.010
Installing drilling plant	77.21	0.009
Removing and storing drilling plant	18.00	0.002
Operating drills	453.95	0.051
Furnishing steam for operating steam drills	114.16	0.013
Cleaning rock for drills and moving same	100.66	0.011
Blacksmith on ledge tools and pipe fittings	382.57	0.043
Blasting and care of explosives	182.29	0.020
Breaking stone	1,362.42	0.152
Hand drilling (block holes)	515.55	0.058
Loading stone	1,010.87	0.113
Removing and loading stripping	124.00	0.014
Weighing stone	181.57	0.020
Weighing stripping	19.67	0.002
Feeding crusher	331.61	0.037
Crusher operation (engineer, fireman, oiler and pitman)	539.74	0.060
Crusher repairs	55.54	0.006
Absent with pay	27.58	0.003
Holidays	705.75	0.079
Teaming:		
Buildings	4.50	0.001
Drilling plant	3.00	0.000
Hauling stone to crusher	929.28	0.104
Hauling stripping	111.47	0.012
Hauling product to pile	281.15	0.031
Total	$7,907.65	$0.882

TABLE B—Continued.

Material, Rental, Interest and Depreciation	Amount	Cost	Cost per ton figured on output
Ledge:			
Blacksmith's coal	1.32 tons	$ 5.54	$0.001
Battery repairs		4.86	0.001
Dynamite, 75 per cent, 1½ in.	1,059.7 lbs.	214.60	0.024
Dynamite, 75 per cent, 1¼ in.	641.0 lbs.	129.80	0.015
Dynamite, 60 per cent, 1¼ in.	356.0 lbs.	63.22	0.007
Black powder	6.0 lbs.	0.66	
Connecting wire	50.0 ft.	0.28	
Electric fuses	389.0		
8 feet long	49	2.13	
10 feet long	19	0.92	
12 feet long	257	13.67	0.005
14 feet long	64	3.71	
Cotton fuse	3,522.0 ft.	10.15	
Percussion caps	1,183.0	8.88	
Stone dust for tamping holes	3.0 tons	3.00	
Cylinder oil	19.75 gals.	6.32	
Machine oil	3.75 gals.	0.64	0.001
Waste	22.0 lbs.	1.65	
Steaming coal	30.02 tons	126.11	0.014
Rental of small tools (at $0.05 per man per day) 1.815 man days (excluding blacksmith and helper) at $0.05		90.75	0.010
Rental and repairs of steam drills (including piping, hose, etc.), 153 drill days at $0.50		76.50	0.008
Buildings:			
Spruce lumber (3 in. by 4 in.)	337 ft. B. M.	8.43	
Spruce lumber (⅞ in.)	430 ft. B. M.	11.18	
Pine lumber (sheeting)	250 ft. B. M.	11.25	
Rex roofing paper	3 rolls	6.75	0.004
Nails	30 lbs.	0.75	
Screws (No. 12, 1½ in.)	10	0.09	
Strap hinges	1 pair	0.09	
		$801.94	

TABLE B—Continued.

Carried forward		$ 801.94	
Crusher:			
Steaming coal	30.03 tons	126.10	$0.014
Cylinder oil	14.5 gals.	5.28	
Machine oil	125.93 gals.	22.17	0.003
Waste	50.75 lbs.	3.81	
Sal soda	48.0 lbs.	0.36	
Rosin	1.0 lb.	0.04	0.001
Belt lacing	300.0 ft.	4.50	
Sheet steel (11½ in. by 1¼ in.)	14.0 ft.	6.00	0.001
Crusher plates (two new, over half worn) at $211.80 less 50 per cent		105.90	0.012
Rubber belting installed (new), $89.12, less 90 per cent		8.91	0.001
Rental on small tools (at $0.05 per man per day), 250 man days (exclusive of engineer, fireman, oiler and weigher), at $0.05		12.50	0.001
Interest and depreciation on plant, three mos. at $149.25		447.75	0.050
Adjusting scales		4.76	0.001
Total		$1,550.51	$0.174
Labor and teaming		7,907.65	0.882
*Total charged to output		$9,458.16	$1,056
Permanent repairs:			
Repairs to scales		68.44	0.008
Total cost of test		$9,526.60	

* Does not include estimated cost of stripping done prior to beginning of test, amounting to $223.83, and does not include cost of quarrying 200 tons of stone remaining unbroken at end of test, amounting to $50.

A COMPARISON OF GYRATORY AND JAW CRUSHERS; THE FIELD IN WHICH EACH IS SUPERIOR

Jaw and gyratory crushers are the two distinct types of crushers extensively used for the preliminary reduction of rock and ore. The well known Dodge and Blake crushers are the best examples of the jaw type and have been widely used for many years. Aside from some modifications in the method of applying the thrust and in the construction of the frame, these machines as built today are similar to the early designs. The gyratory type of rock breaker was introduced about 1885. Its large capacity was its most attractive feature and led to its rapid introduction. The early designs were faulty in many features. There is an improved design which has become more or less standard with the several manufacturers. This is the suspended-shaft, two-arm spider, drop-bottom type, with cut-steel bevel gears, forced oil circulation, manganese-steel crushing head and concaves.

Since it is possible to purchase either type of crusher in almost any size and with the assurance that the design and construction are adequate for the work intended, the choice of type can be made strictly on the basis of suitability and economy. There are fads in machinery as well as in millinery. The rapid development of the gyratory crusher, and its success in meeting severe requirements have led many to advocate the complete retirement of the jaw type. Each type has a field in which it is superior, and it is easy to define the limits of each. There are certain advantages and disadvantages that are inherent in each type of machine, irrespective of size or service, and these are generally fairly well recognized. Of greater importance and less generally appreciated, are the characteristics of each machine for a particular size and service.

Table I has been prepared to show at a glance the comparative features of the two types over a wide range of sizes and services. All the machines quoted in the table, except the two largest sizes of gyratory crushers, are standard sizes. The weights, capacities, required power, etc., are those guaranteed by the manufacturers for average conditions with hard, friable rock. The machines quoted in the table to deliver a certain sized product are the medium sizes adapted to that product, as both larger and smaller machines, within small limits, could be adjusted to produce a certain size of material. The particulars of the 36x282-in. and the 42x345-in. gyratory crushers are only approximate, as the largest standard size manufactured is 24x198 ins. Gyratory crushers larger than 24x198 ins. have been built to special design.

Size of Feed. Inspection of the compiled and calculated data in Table I reveals the following interesting comparisons: It develops that in each case the gyratory is a machine of greater weight, capacity and horsepower than the Blake crusher for the same size feed and product. The feed opening of the Blake type is rectangular, that of the gyratory is necessarily the seg-

ment of a ring. From this fact it follows that the weight and capacity of a gyratory crusher will increase more rapidly with an increase in the width of the receiving opening than will the Blake type. In other words, we may vary the width or the length of the feed opening in the Blake type independently of each other, while in the gyratory type the width of the feed opening controls the entire design, and the whole machine must be proportioned accordingly. This is an important characteristic and has great influence in defining the field of each type.

Weight, Capacity and Horsepower. Table II, which is computed from the data given in Table I, indicates a notable superiority of the gyratory type as regards efficiency of power consumption and capacity per ton weight of crusher. In all cases tabulated, except the first (crushing from 7 to 1½ ins.), the relative capacity of the gyratory is greater than either the relative weight or required power. Referring to the third column of Table II, it appears that in this case the weight of the gyratory is 1.6 times that of the Blake crusher for the same size feed and product, but the capacity of the gyratory is 2.8 times that of the Blake, and the relative power required is only 1.66. This comparison between the two types is also emphasized by the values of capacity per installed horsepower which were computed for Table I. The gyratory is shown to vary from 0.58 ton per hour installed horsepower, in the smallest size tabulated, to 4.80 for the largest size, while the Blake has the values 0.50 to 2 for the same conditions. The greater duty per installed horsepower in the gyratory type is due to several reasons. A jaw crusher must break a rock by simple compressive force, high stresses being obtained by impact. The gyratory has the advantage of breaking a large number of pieces by beam action because of the concave shape of the shell and the convex shape of the crushing head. This action introduces both compressive and tensile stresses in the piece of rock, causing it to break with less exertion of force because the tensile strength of rock or ore is only a fraction of its compressive strength.

The gyratory is more economical of power owing to its continuous action. A jaw breaker consumes a large amount of energy in overcoming the inertia of the heavy and rapidly reciprocating parts. Another feature which helps to account for the relatively large amount of power that is installed for Blake crushers is the intermittent character of the work. The demand is irregular, and may temporarily far exceed the average, so a crusher of the jaw type must be liberally equipped with power.

Comparison of Operating Advantages. Reference to Table I shows the marked advantage of the Blake over the gyratory type as regards the height of crusher. This is an important item, as it controls the height of buildings. In addition to the greater actual height of the gyratory it requires much clear headroom both above and below the machine for the necessary raising and lowering of the parts. The floor space occupied is about the same for either machine for a certain size feed and product.

The concave shape of the rigid shell of the gyratory, resulting in breaking some of the rock by beam action, causes the material to be more cubical in form than the product of a jaw crusher. For this reason the gyratory usually gives the most uniform product from a given ore or rock.

Other conditions being equal, there is less actual wear on the liners of a jaw crusher, because the tendency toward a certain grinding action cannot be entirely eliminated from the gyratory type. Owing to the conical shape of the concave liners of a gyratory they cannot be reversed when worn at the bottom. The plates for a jaw crusher can be arranged to be turned end for end when the lower part becomes badly worn. For these reasons the renewals for the gyratory type are a greater expense than in the jaw type.

Provided the feed is previously reduced to proper size, attendance is the same for one machine of either type, which gives an important advantage to the gyratory in those cases where its larger capacity enables it to replace two or more jaw crushers.

Repairs. Repairs are more difficult to make, and possibly more frequent, with the gyratory type. The critical mechanical feature of the gyratory is the eccentric drive on the lower end of the main shaft. With hard rock and heavy feeding it requires efficient lubrication to keep the bearings cool. A well designed Blake crusher is easier to keep in order. The introduction of steel castings for the main frame of the jaw crushers has increased the strength and lessened the weight of that important part. As regards vibration during operation the gyratory is superior, as it runs very steadily.

The consideration of relative merits for a specified capacity, and the comparisons drawn therefrom are all on the basis of a given size of feed and product. It would be desirable to compare the two types on the basis of given capacity as well as size of feed and product, but this is not possible. When we designate the feed and product, the size and capacity of the appropriate crusher of each type is determined thereby, and these vary widely for the two types. The bearing that the required capacity has upon the comparison of merits, although left for the last, is all-important, as will be shown.

Consider the case in the first column of Tables I and II. This is the only case of those tabulated in which the gyratory does not excel in capacity per ton weight of machine. If, however, a particular installation required the capacity afforded by the 7x56-in. gyratory (seven tons per hour), it might be selected in place of two 10x7-in. Blake crushers, because of the economy of one machine, one foundation, and one attendant. If, however, advantages are to be gained, as in small stamp mills, by dividing the work between several small crushers so as to avoid conveying the crushed material and to gain bin storage without additional height, two small Blake crushers might be selected in preference to one gyratory. It should be noted that the relative weight of the two types is not an exact index of the relative first cost,

because the gyratory crushers are sold at a higher price per pound than the Blake type. There are other factors affecting first cost besides the price of the machine at the manufacturer's works.

Rock Breakers vs. Bulldozing. Referring to the last columns of the tables, there is a most interesting case which is not generally well understood. We are dealing with large receiving openings and coarse crushing. During the last few years a demand has arisen for crushers of this magnitude in order to introduce economies in the mining and milling of ores. It has long been recognized that rock breaking is cheaper than stamp milling down to a size of about 1 in., and now it is beginning to be understood that rock breaking is cheaper than bulldozing and sledging pieces several feet in each dimension. This, of course, applies only to large-scale operations where the amount to be handled and the transportation equipment render such an installation feasible. To show the economies possible in this direction it may be noted that at the Treadwell mines in 1903* the amount of powder used in stoping was 0.34 lb. per ton of ore mined, while it required 0.85 lb. per ton mined to bulldoze this rock after it was stoped. It required one man breaking rock for each machine drill. Much labor was necessary on the feed floor of the crusher. The gyratory crushers in use did not receive large pieces. It is understood that improvements in this direction are now planned.

Returning to the tabulated features of the crushers with large feed opening, one is impressed at once with the enormous capacity and colossal size of the gyratory machines for this class of work. While the calculations show that the gyratory crushers in these sizes have marked advantages in efficiency, their tremendous size and cost are prohibitive unless their large capacities can be utilized. The 36x282-in. gyratory is estimated to have a capacity of 900 tons per hour to a 12-in. product, and the 42x345-in. 1,200 tons per hour to 16-ins. It would be a remarkable mining or quarrying operation that would furnish large material at such a rate, and that is why we do not hear of gyratory crushers of such dimensions. Some machines have been built larger than 24x198-in., but they are not likely to come into general use. On the other hand the large Blake crushers are commonly built and successfully installed. Their capacity is usually in excess of the requirement but, as is evident from Table I, not to the prohibitive extent that is true of the gyratory type.

Crushing Plant for 200-Stamp Mill. As an illustration of the application of the preceding data and conclusions, the design of a crushing plant for a 200-stamp mill will be considered. Assume a wide body of hard ore, which can be mined cheaply if the ore does not have to be blasted beyond what is necessary to break it from the solid, and adequate transportation facilities are provided to convey the large material to the crushing house. I further assume that a knowledge of the character of the vein

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* The Treadwell Group of Mines, Douglas Id., Alaska, by R. A. Kinzie, Trans. A. I. M. E., 1904.

and the general conditions of mining are such that it will be desirable to provide for receiving pieces up to 36x42 ins. Assume that the stamps have a capacity of 5 tons per day, then for the 200-stamp mill 1,000 tons per day crushed to pass a 1¾-in. ring **(equivalent to 1¼-in. cube) must be delivered by the proposed**

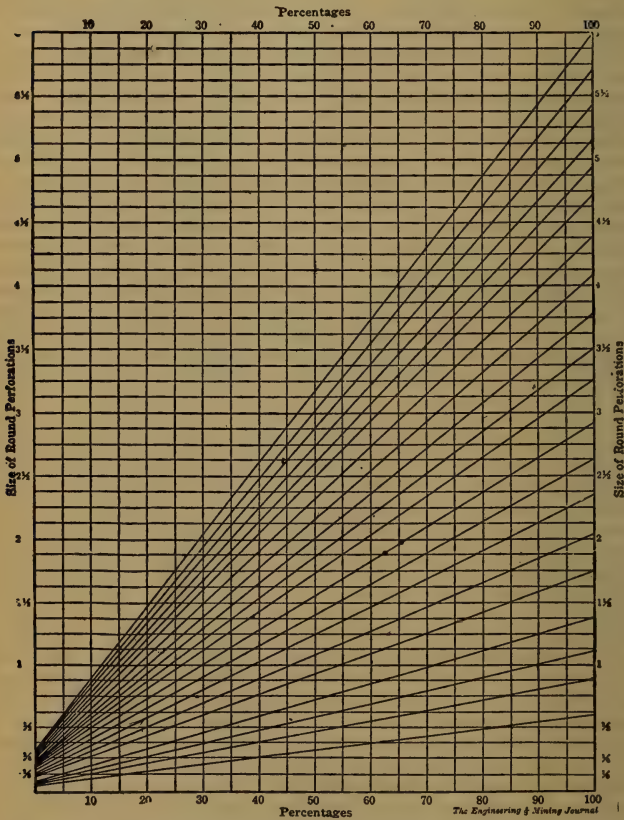

Fig. 75a. Diagram Showing Proportions of Rock Crushed to Various Degrees of Fineness.

crushing plant. It is apparent that the ore must be crushed in stages. Since the initial crushers of large receiving opening will of necessity have a large capacity, it will be best to concentrate the crushing into one 8-hour shift, thus introducing

economies in operation. This calls for a crushing capacity of 125 tons per hour.

In Table III the distribution of sizes in run-of-mine ore is obtained from experience. The percentages of the different sized particles in the product delivered by any particular crusher may be found by consulting the diagram shown in Fig. 75a. For example, when crushing to pass a 6-in. ring, 81 per cent will pass a 5-in., and about 20 per cent will go through a 1½-in. ring. This diagram was constructed by the Power and Mining Machinery Co., and is stated to be the result of the compilation of a large amount of experimental data. The results obtained are stated to have been uniform, and the diagram is recommended to be used to determine the percentages of certain sized products from any crusher, roll, or screen. The diagram is approximately correct for hard friable ore, and proper allowance must be made if the rock has any inherent tendency to break in a certain way.

Taking the required capacities and duties as arrived at in Table III and referring to Table I, it is apparent that we would select the 42x36-in. Blake crusher for the initial breaker. This machine has excess capacity over what is required, but not such enormous excess cost and capacity as a gyratory for the same work. For the secondary crushing one 12x88-in. gyratory is strikingly superior, as it would require three 24x12-in., or two 40x12-in., or two 36x18-in. Blake crushers for the same capacity. For the final crushing two 10x80-in. gyratory crushers would be indicated.

If the ore foundation and conditions of mining and transportation were such that an initial crusher to receive pieces 24x36-in. was sufficiently large, it would be found, upon making a size analysis similar to that shown in Table III for 36x42-in. that one 36x24-in. Blake machine crushing to 4-in., followed by two 10x80-in. gyratory crushers each giving a product to pass a 1¾-in. ring, would meet the conditions.

In an installation of the size considered above, the crushing plant would be separated from the mill, the crushed product being delivered to the ore bins by conveyers. The large initial crusher must have a solid foundation, preferably resting directly on the ground. The large pieces to be handled make it imperative that the ore be dumped into a receiving hopper that feeds directly to the large crusher. If a gravity-plant site is not available or desirable, there is no difficulty in elevating the product of the initial crusher for further reduction.

The conclusions reached above are in accordance with the most advanced practice. The economy of breaking by crusher over bulldozing and sledging is beginning to be appreciated. Recent installations in South Africa employ large Blake crushers for initial breakers, followed by gyratory machines preliminary to stamp milling. A notable installation in the United States is that of a 60x42-in. Farrell-Bacon jaw crusher capable of breaking down to 16-in. the largest pieces of hard iron ore that can be handled by a 70-ton steam shovel. Other plants where economies

have been secured by introducing large initial crushers of the Farrel-Bacon jaw type are the Granby mines, Phoenix, B. C., the British Columbia Copper Company and the Natomas Consolidated of California.

In conclusion it may be said that while each type has a field in which it is superior, no sharp lines can be drawn because of the many factors involved. It is believed, however, that with the aid of the data here presented an investigation along the lines indicated will quickly disclose the most desirable machine for any particular service.

Note particularly that the capacity in tons per hour of a crusher is a very uncertain quantity. The data in these tables have been gathered from various sources and are believed to be fairly accurate, but the author disclaims responsibility for what any one crusher may do on any particular job or on any particular kind of rock. The only safe course is to leave a liberal margin for contingencies. The guaranteed capacity of a manufacturer, even if accompanied by specifications and a contract may mean only the guaranteed capacity for a run of an hour, and at the end of the hour the machinery may need to stand still for another hour to cool off. Crushers have been sold on such a basis more than once to the sad discomfiture of the contractor.

TABLE I.—COMPARATIVE FEATURES OF JAW AND GYRATORY CRUSHERS.

Crushing from	7 to 1½ in.		10 to 1¾ in.		12 to 2½ in.		18 to 3½ in.		24 to 5 in.		36 to 12 in.		42 to 16 in.	
Type of crusher	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory
Size of feed opening in in.	10x7	7x56	20x10	10x80	24x12	12x88	36x18	18x136	36x24	24x198	42x36	36x282	60x42	42x345
Capacity in tons per hr..	4	7	12	30	25	70	60	130	85	400	160	900	300	1200
Weight in tons..........	4	8	9	18	15	24	29	50	30	95	55	200	100	300
Hourly cap. ÷ tons wt....	1	0.87	1.25	1.66	1.67	2.91	2.07	2.60	2.83	4.22	2.90	4.5	3	4
Installed horsepower	8	12	20	25	30	50	65	90	65	150	100	200	150	250
Hourly cap., installed h. p.	0.5	0.58	0.60	1.20	0.83	1.40	0.92	1.44	1.31	2.67	1.60	4.5	2	4.8
Height in ft. (discharge spout to feed floor)....	3	5½	3	7½	5	8	6	10	6	15	7	23	8	26
Width in ft. (including pulleys)	6½	10	7	13	8	13	13	13	13	20	13	27	15	30
Length in ft. (over all)..	5½	5	9	6	10	6	12	12	12	12	15	18	16	21

TABLE II.—RELATIVE WEIGHTS, CAPACITIES AND HORSEPOWER.

The Blake Crusher being taken as unity in each case.

Crushing from ...	7 to 1½ in.	10 to 1¾ in.	12 to 2½ in.	18 to 3½ in.	24 to 5 in.	36 to 12 in.	42 to 16 in.
Relative weight of gyratory	2.0	2.0	1.60	1.72	3.16	3.65	3.00
Relative h. p. of gyratory	1.50	1.25	1.66	1.39	2.32	2.00	1.68
Relative capacity of gyratory	1.75	2.5	2 80	2.17	4.72	5.62	4.0

TABLE III.—SIZE ANALYSIS.

Crushing Plant Designed for 125 Tons per Hour.

	Tons per Hour Between			
	36 and 12 in.	12 and 3 in.	3 and 1¾ in.	1¾ in. and under
Run in mine	55	40	15	15
Feed to first crusher	55	..	..	..
Product of first crusher	..	30	15	10
Feed to second crusher	..	70	..	..
Product of second crusher	..	..	30	40
Feed to third crusher	..	..	60	..
Product of third crusher	..	..	..	60

In asking for estimates on crusher plants, the following information should be given the manufacturer:

The nature of the material to be crushed.

Tons or cubic yards to be crushed per day of ten hours.

Sizes into which the material is to be screened.

The different sizes to be obtained.

Storage capacity for crushed stone desired.

(This information will enable the determination of the proper length of elevator if one is needed.)

Whether power plant is wanted.

(If so, kind of power preferred, steam or electrical. If electrical, advise whether direct or alternating current, and voltage, phase and cycle.)

System of delivering rock to the crusher best fitted to local conditions:

A—Incline and automatic dump cars.
B—Level with end dump cars and tipple.
C—Level with side dump cars.
D—Incline chute.
E—Incline track.
F—Dump cars on tramway.
G—Horse and cart.

Give an idea as to the character of the ground in the proposed location; whether level or on a hillside. If on a hillside, give approximately the grade with a rough sketch of the site, if possible, showing the position of the quarry relative to the plant and the position of railroad tracks.

Answers to the above questions, together with such other suggestions and directions as may be offered by a prospective customer, will facilitate very much the preparation of plans and the selection of appropriate machinery for the plant.

DERRICKS

LIGHT DITCH DERRICK

3″x4″ spruce, 12′ high, with drum, gear and cranks........	$50.00
4″ square spruce, 14′ high..............................	60.00
3 leg tripods, 12′ high, no gear........................	16.00
3 leg tripods, 14′ high, no gear........................	18.00

All ironed and painted. No rope or block.

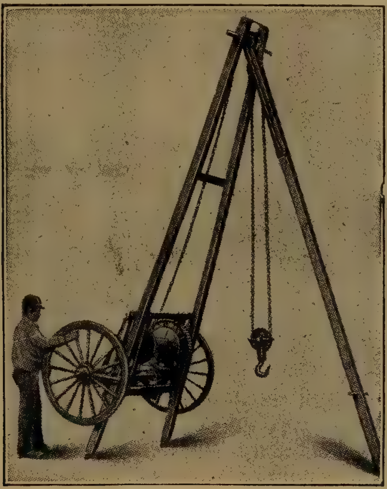

Fig. 76.

TRIPOD DERRICK OF PIPE AND DROP FORGED FITTINGS

No.	Size of pipe legs	Weight	Safe capacity	Price
1	1 ″x 7 ′	38 lbs.	1000 lbs.	$ 3.75
2	1 ″x 8½′	45 lbs.	1000 lbs.	4.10
3	1½″x10 ′	88 lbs.	2000 lbs.	6.75
4	1½″x12 ′	100 lbs.	2000 lbs.	7.50
5	2 ″x12 ′	145 lbs.	3000 lbs.	10.50
6	2 ″x14 ′	165 lbs.	3000 lbs.	11.50

Sulky derrick about 15′ high. One man, one ton, with brake, blocks and 50′ of ½″ steel wire rope or 100′ of 1″ manila rope. Weight, 3,500 lbs. Price, $60.00. See Fig. 76.

LIGHT DERRICKS WITH WINCHES OPERATED BY HAND POWER

Fig. 78. These can also be operated by an engine and can be set upon a small car.

Fitted with manilla rope for light work. Sheaves arranged for three lines in the boom tackle and two lines in the hoisting tackle.

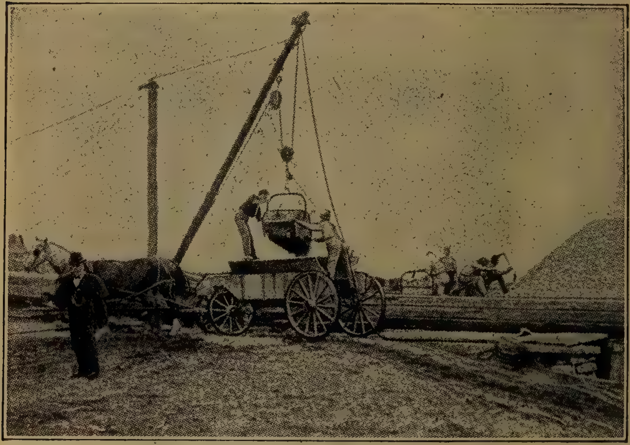

Fig. 77. Plant for Loading Earth.

1 Derrick, 1500 lbs. capacity with 18′ mast and 18′ boom..	$46.50
100′ of ¾″ pure manilla rope, estimated for boom line, at 4c ft.	4.00
150′ of ¾″ pure manilla rope, estimated for fall line, at 4c ft.	6.00
300′ of ⅞″ pure manilla rope, estimated for 4 guy lines at 5c ft.	15.00
3 7″ single wood blocks for hoist and boom line, at 75c....	2,25
1 boom winch, used for operating the boom	12.00
Total	$85.75

Same outfit with 16′ mast and 16′ boom	$85.25
Same outfit with 14′ mast and 14′ boom	84.75
Same outfit with 12′ mast and 12′ boom	84.25
1 light car, 4′x6′, with flat wheels, complete	25.00
1 No. 1 light car, 4′x6′, with flanged wheels, complete	28.00

All derrick irons for derrick (no rope, blocks, boom winch or timbers, but with drawings for mast and boom)..... 31.50

FITTED WITH STEEL HOISTING CABLES FOR HEAVY WORK

Sheaves arranged for three lines in the boom tackle and three lines in the hoisting tackle.

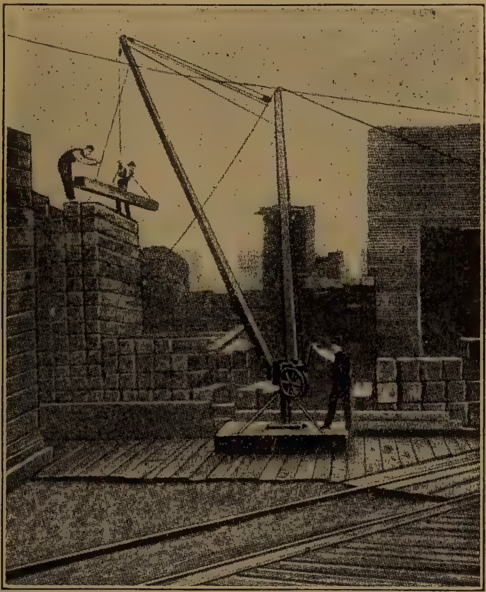

Fig. 78. Parker Derrick No. 4—Hand Power.

1 Derrick, capacity 1500 lbs., with 18′ mast and 18′ boom..	$ 46.50
100′ of ⅜″ best flexible steel cable, estimated for boom line at 7c ft.	7.00
200′ of ⅜″ best flexible steel cable, estimated for fall line at 7c ft.	14.00
300′ of ⅞″ pure manilla rope, estimated for 4 guy lines at 5c	15.00
3 8″ single steel blocks for ⅜″ cable, with plain hooks, at $4.50	13.50
1 8″ single steel block for ⅜″ cable, with swivel hook...	9.00
4 ⅜″ Crosby clips, at 20c.	.80
2 ⅜″ galvanized thimbles, at 10c.	.20
1 No. 1 boom winch, used for operating the boom.	12.00
Total	$118.00
Same outfit with 16′ mast and 16′ boom.	$118.00
Same outfit with 14′ mast and 14′ boom.	117.50
Same outfit with 12′ mast and 12′ boom.	116.50
1 Light car, 4′x6′, with flat wheels, complete.	25.00
1 Light car, 4′x6′, with flanged wheels, complete.	28.00

All derrick irons for derrick (no rope, block, boom winch or timbers, but with drawings for mast and boom).....	$ 31.50
Price of two wooden stiff legs (complete) to take the place of 4 guy lines..........	15.00
Price of two wooden stiff legs (irons only) to take the place of 4 guy lines..........	10.00
2 single sheave brackets for steam power..........	5.00

In building 1,000 ft. of 15″ pipe sewer at Big Rapids, Mich., a trench 4′ wide and about 15.5′ deep was dug in gravel and boulders. About 8 cords of stone, many of them large size and near the bottom of the trench, were removed. A fuller description of this work is in Gillette's "Cost Data," p. 817.

The first 5′ were taken out with a scraper and a team and driver. The remainder was removed in buckets with a derrick of the above type. About 50′ of sewer were completed per day at the following cost:

	Per Day
1 foreman at $2.00..........	$ 2.00
1 scraper team and driver at $3.75..........	3.75
1 man holding scraper at $1.50..........	1.50
1 man dumping scraper at $1.50..........	1.50
2 men pulling sheeting and carrying it at $1.50..........	3.00
1 man pulling sheeting and carrying it at $1.50..........	1.50
1 horse and driver on haul line at $2.50..........	2.50
4 men filling two 1-6 cubic yard buckets at $1.50..........	6.00
1 man laying pipe and $2.00..........	2.00
1 pipe layer's helper at $1.50..........	1.50
Total	$25.25

This gives a cost of 50.5 cents per lin. ft. of sewer. The actual cost of excavation was 20 cents per yd. for scraper and 12.6 cents for derrick work. The derrick was moved two or three times a day, which took about seven minutes each time.

Fitted with Steel Cable for Heavy Work. Sheaves arranged for three lines in the boom tackle and three lines in the hoisting tackle.

1 Derrick, capacity 4000 lbs., with 20′ mast and 30′ boom..	$ 76.00
150′ of ⅜″ best flexible steel cable, estimated for boom line, at 7c ft..........	10.50
300′ of ⅜″ best flexible steel cable, estimated for hoisting line, at 7c ft..........	21.00
300′ of ⅞″ pure manilla rope, estimated for 4 guy lines, at 5c ft.	15.00
3 8″ single steel blocks, with plain hooks, for ⅜″ cable, at $4.50	13.50
1 8″ single steel block, with swivel hook, for ⅜″ cable....	9.00
4 ⅜″ Crosby clips, at 20c..........	.80
2 ⅜″ galvanized thimbles at 10c..........	.20
1 boom winch, used for operating the boom..........	14.00
Total	$160.00
Same outfit with 20′ mast and 24′ boom..........	157.25
Same outfit with 18′ mast and 18′ boom..........	154.50
1 Light car, 6′x8′, with flat or flanged wheels, complete...	30.00
All derrick iron for above (no ropes, blocks, timbers or boom winch, but with drawings for mast and boom)....	53.50
Price of 2 wooden stiff legs (complete) to take the place of 4 guy lines..........	20.00
Price of 2 wooden stiff legs (irons only) to take the place of 4 guy lines..........	12.00
2 Single sheave brackets for steam power..........	6.00

Special Outfit Designed for Lumber Yards. Fitted with steel hoisting cable. Sheaves arranged for three lines in the boom tackle and three lines in the hoisting tackle.

1 Derrick, capacity 4000 lbs., with 20′ mast and 30′ boom..	$76.00
150′ of ⅜″ best flexible steel cable, estimated for boom line, at 7c ft.	10.50
300′ of ⅜″ best flexible steel cable, estimated for fall line, at 7c ft.	21.00
300′ of ⅞″ pure manilla rope, estimated for 4 guy lines, at 5c ft.	15.00
3 8″ single steel blocks, with plain hooks, for ⅜″ cable, at $4.50	13.50
1 8″ single steel block, with swivel hook, for ⅜″ cable...	9.00
4 ⅜″ Crosby clips at 20c	.80
2 ⅜″ galvanized thimbles at 10c	.20
1 No. 4 boom winch, used for operating the boom	14.00
Total	$160.00

Same outfit with 20′ mast and 24′ boom	157.25
Same outfit with 18′ mast and 18′ boom	154.50
1 extra heavy lumber yard car, 6′x8′, with flat or flanged wheels, complete	50.00
1 8″ snatch block for ⅜″ cable, with chain, for horsepower use	5.00
1 pair skidding tongs, open up to 10″	2.25
1 pair skidding tongs, open up to 14″	3.00
1 pair skidding tongs, open up to 20″	5.00

Shipping weights vary from 300 lbs. to 2,500 lbs., according to size.

All irons for 1,500-lb. derrick weigh approximately 300 lbs.
All irons for 4,000-lb. derrick weigh approximately 550 lbs.

HAND POWER BREAST OR BUILDERS' DERRICKS.

Length of timbers (feet)	16	24	40
Size of timbers (inches)	4 x 6	6 x 8	8 x 8
Diameter of drum (inches)	6	6	9
Length of drum (inches)	42	60	72
Price complete without timbers or rope	$36.00	$45.00	$58.50
Price complete without rope	56.70	67.50	100.00

Derricks for operation by steam engine cost:

5 ton stiff-leg derrick with bull wheel and 30′ boom	$350.00
10 ton guy derrick with 50′ boom	550.00
15 ton guy derrick with 65′ boom	650.00

Mr. Saunders gives the following detailed cost of a large quarry derrick with a capacity on a single line of 20 tons.

Timber for mast 24″x24″x75′	$ 45.00
Timber for boom 65′	28.00
Expense of delivering timber	16.50
Carpenter work on mast and boom at $12.50 a day	25.00
Derrick irons, sheaves	219.00
2,400′ of best galvanized 1″ iron rope for 8 guy	237.00
Thimbles, clamps, etc.	25.00
500′ steel hoisting rope, 1⅝″	240.00
Labor on dead men, 4 men, 2 days at $1.40	11.20
Labor raising derrick, 8 men, 2 days at $1.40	22.40
Labor fixing guys, 8 men, 2 days at $1.40	22.40
Total	$891.50

Stiff-leg derrick complete capable of operating ¾-yard clam-shell bucket on a 50′ boom. Equipped with 8′ bull wheel, guide sheaves, framed complete with all irons. Boom 12″ x 12″ x 50′; mast 10″ x 10″ x 32′; stiff legs 10″ x 10″, framed 10 horizontal to 12 vertical; sills 10″ x 10″. Price, $415.00 f. o. b. N. Y.

RIGGING FOR STIFF-LEG DERRICK

1 14″ single block with shackles	$10.50
1 14″ double block with shackles	15.50
310′ of 4 part topping line	.....
115′ of 4 part bull-wheel line with clips	26.00
425′ of ⅝″ C. C. S. wire rope	.....
300′ of 3″ holding and closing line	26.00
Total	$78.00

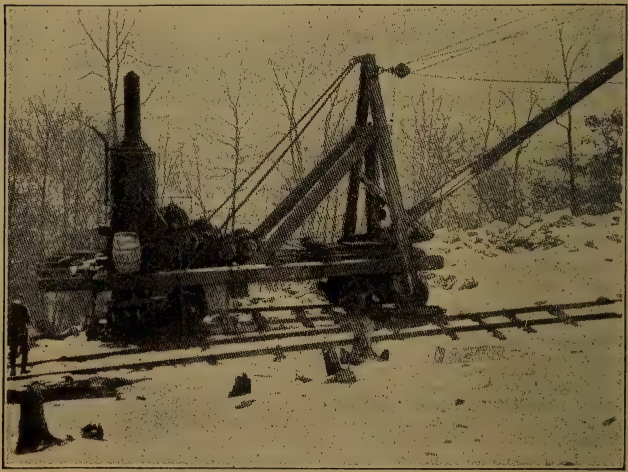

Fig. 79.

Derrick fittings bought for second-hand derrick of similar description as above for use with 3 drum hoist and a clam shell bucket cost as follows:

1400 lineal feet ⅝″x6x19 crucible steel W. R. cable	$102.33
3 14′ double bronzed bushed blocks at $13.75	41.25
1 14′ single bronzed bushed blocks	9.35
2 12″ sheaves bronzed bushed blocks at $1.75	3.50
12 guy clamps and bolts for ⅝″ rope at 24c	2.88
1 12″ snatch block bronze bushed	11.55
Total	$170.86

A car provided with an A frame, a hoisting engine and light jack arms, capable of lifting 5-ton boulders, etc., costs from $1,500 to $2,000 new. See Fig. 79.

IRONS FOR POWER-OPERATED STIFF-LEG DERRICKS

The following list, to accompany Fig. 80, enumerates the most important metal parts of stiff-leg derricks to be operated by power. It does not include guide sheaves, blocks, or other running gear.

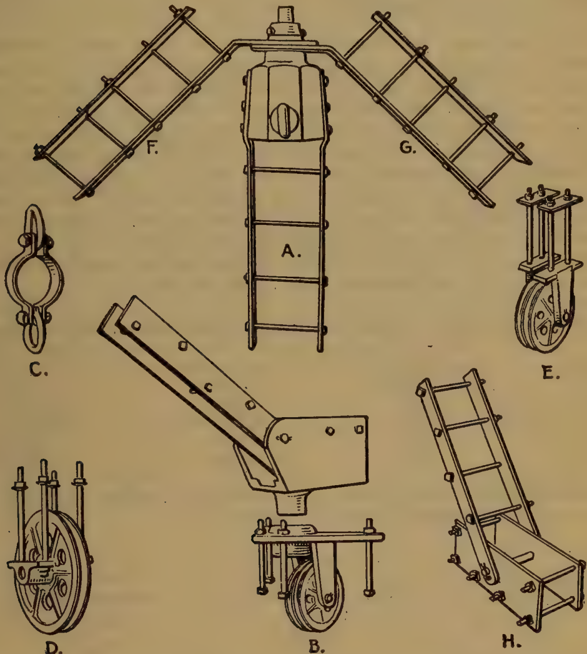

Fig. 80. Iron Work Complete for Power Stiff-Leg Derrick—As Regularly Furnished.

A. 1 Mast Top with straps and gudgeon pin.
B. 1 Mast Bottom complete with step, double sheaves and strap for boom.
C. 1 Flat Bolted Boom Band with 2 links.
D. 1 Single Boom Sheave with boxes, for center of mast.
E. 1 Double Sheave Mast Bracket.
F. 1 Top Stiff Leg Iron.
H. Lower Stiff Leg Irons (two of these furnished), and all necessary bolts.

Prices of derrick (not including timber, engine, bull wheel or guide sheaves, blocks, hoisting rope, clamps or thimbles) are:

Size of mast timber (inches)....	8 x 8	14 x 14	18 x 18
Length of mast (feet)...........	24	40	36
Size of boom (inches)..........	6 x 6	12 x 12	16 x 16
Length of boom (feet)..........	32	54	54
Size of stiff legs and sills (in.).	6 x 6	12 x 12	16 x 16
Capacity in tons................	1 to 2	10 to 12	20 to 25
Shipping weight (lbs.)..........	750	2100	7000
Price with self-lub. sheaves.....	$80.00	$150.00	$375.00

On railroad work in Newark it took six men and a foreman one day to move a stiff-leg derrick with a 50′ boom 150 feet and one day to set it up, at a total cost of $24.00. This includes moving the engine and the stone used to weight the stiff legs. Two guy derricks with 70′ masts and 80′ booms were used for two years in building a concrete filter. During that period they were erected once, moved five times, and finally removed once at a cost of $1,400, an average of $100 per move. As a rule, however, a guy derrick can be shifted more easily than a stiff-leg derrick, as there are no stones to be handled.

Derricks should be provided with a bull wheel where possible, as the wages of two tagmen will soon pay for it.

Sizes and prices of steel bull wheels complete with braces:

Diameter, feet	For booms, length in feet	Weight complete	Price
8	40	1600	$ 85.00
12	60	2000	110.00
14	70	3000	215.00
16	80	3700	280.00

Guide sheaves and rollers in frame for leading rope from bull wheel to swinging drum of engine:

Diameter of large sheaves (inches)	Price: Common sheave	Price: Self-lubricating sheave
10	$ 4.50	$ 5.25
14	6.75	9.25
18	11.00	14.75

A derrick formerly known as the Kearns derrick was used in the construction of a 14′ concrete sewer at Louisville, Ky. The sewer was 4,230 ft. long and had an average depth of 39.3′; the average number of yards per ft. was 26.5. The derrick excavated to within 14′ of the bottom, and a Potter machine excavated the remainder and carried it to the rear for backfill. The derrick operated a ¾-yd. clamshell bucket, which loaded into wagons for spoiling or into Koppel cars for backfill. The output was about 1,500 cu. yds. per week.

The machine consisted of a stiff-leg derrick mounted on a turn-table. The power plant was a 7 x 10 in. engine with three drums, and a 30 H. P. boiler. The entire outfit cost about $6,500.

FLOATING DERRICKS.

(See also Boats.)

A floating derrick was purchased by the city of Chicago in 1905 at a cost of $5,287.26. It was used on the hydraulic filling of the Lincoln Park extension in 1910 for various purposes. It was in commission ten hours per day and was operated by a crew consisting of an engineer, fireman and a varying number of deck hands, usually four. The cost of operation during 1910 was as follows:

Hours in commission	1,783.50
Labor of operation	$1,871.29
Fuel and supplies	599.07
Insurance	100.00
Labor repairs	268.70
Towing	17.62
Total	$2,856.68
Total cost of repairs	286.32
Total cost of operation	2,570.36
Total cost per hour	1.60
Total cost per day	16.00

During 1911 the derrick was in commission for 440 hours with a crew of two men, and for 1,254 hours with a crew of six men. The cost of operation and repairs for the 1,694 hours in service is given as follows:

COST OF DERRICK OPERATION AND REPAIRS.

Operation		Per hour
Labor, watching	$ 178.67	
Fuel	237.68	
Supplies	244.63	
Insurance	96.50	
	$ 757.48	$0.45
Repairs		
Labor	$ 188.70	
Material	140.75	
Teams	14.00	
	$ 343.45	$0.20
Total operation and repairs, excepting operating labor	$1,100.93	$0.65
April 1 to Aug. 1, 440 hrs.		
Operating labor	$ 568.55	$1.29
Fuel, supplies and repairs	.....	0.65
Cost per hour, 440 hours	.....	$1.94
After Aug. 1, 1,254 hours.		
Operating labor	$3,155.95	$2.52
Fuel, supplies and repairs	......	0.65
Cost per hour, 1,254 hours	.....	$3.17
Total cost for year	$4,825.43	

DIVING OUTFITS

A diver's outfit consists of a metal helmet or head covering, a breast plate, an air-tight diving suit, and shoes with weights. Weights are also attached to his waist to overcome buoyancy. The helmet always has one window in front, usually one on each side, and sometimes one near the top. The air hose runs from the pump to a valve either in the helmet or breast plate. Besides this one, a safety and a regulating valve for controlling the pressure are provided. The diver is raised or lowered by a rope attached to his waist called the safety line.

The air pump is always operated by hand power, may have from one to three cylinders, may be single or double acting, and of either the lever or fly-wheel type.

The prices of diving apparatus are as follows:

Helmets, $100; suits, $30 to $60; other equipment, $100 to $150; air pumps, $100 to $400. The cost of a complete outfit varies with the depth of water where it is to be used. For shallow water an outfit costs from $300 to $450; for moderate depth, $450 to $700; and for deep sea diving, $700 to $800.

The net weight of helmets varies from 37 to 74 pounds.; gross weight, 77 to 144; shipping space, 5 to 9 cu. ft.

The net weight of air pumps varies from 30 to 1,400 lbs., and shipping space from 3 to 40 cu. ft.

Diving dresses weigh (net) 16 to 32 lbs., and occupy 1½ to 4 cu. ft.

Diving shoes weigh (net) 36 lbs., and occupy 1 cu. ft. of space.

Air hose weighs about 22 lbs. per length of 50 ft. and occupies 2 cu. ft. of space.

Below are given itemized lists of two complete outfits:

DIVING OUTFIT No. 1.

Complete in all respects for one or two divers as supplied for general use of contractors, divers, etc.

1 Air pump, No. 1. Two cylinders, double action with two patent indicating gauges to denote the air pressure and depth of each diver; with water cistern, two fly-wheels in ash chest, with iron rings for lashing...............$500.00

These pumps have removable tills fitted into the pump cases, in which are furnished and packed the following small parts:

1 union joint, double male.
1 union joint, double female.
1 nut for securing pump handles (spare).
1 oil can.
1 overflow nozzle.
12 washers for air hose (spare).
1 socket wrench.

1 screwdriver.
3 double-ended spanners.
1 10-inch monkey wrench.
Spare valves, inlet and outlet.

1 Improved diving helmet, 3 lights, sectional screw, to receive air in the head-piece, or one to receive air in the breast-plate; either style, including safety valve, adjustable regulating valve and recessed gasket seat....	$ 100.00
2 rubber diving dresses; Size No. 2, at $50.00..........	100.00
150 feet standard white air hose (3 pieces) with couplings, at 40c	60.00
1 set diving weights, belt pattern......................	22.00
1 pair diving shoes, with lead or iron soles..............	15.00
2 pairs rubber diving mittens, at $5.00.................	10.00
1 pair rings and clamps...............................	5.00
1 life or signal line (150 feet).........................	2.50
1 pair cuff expanders................................	5.00
1 knife, belt and air-hose holder.......................	10.00
6 feet snap tubing, at 60c............................	3.60
1 pair chafing pants.................................	4.00
1 helmet cushion.....................................	3.00
2 pairs diver's stockings, at $1.25......................	2.50
2 woolen shirts and drawers, at $1.50.................	6.00
2 pairs woolen mittens, at $1.25.......................	2.50
1 woolen cap..	1.25
1 basket for helmet, dresses, hose, etc..................	18.00
6 extra bolts and nuts for helmet (spare), at 25c........	3.00
1 set extra couplings (spare)..........................	2.00
1 yard rubber cloth for repairs........................	2.50
1 can rubber cement for repairs (1 lb.).................	.75
1 cutting punch......................................	.75
Complete outfit for one diver........................	$879.35
Complete outfit for 2 divers will include duplicate of each of the above items except the pump..................	1258.70

For one diver: Net weight, 950 lbs.; gross weight, 1,100 lbs.; shipping measurements, 56 cu. ft.

For two divers: Net weight, 1,260 lbs.; gross weight, 1,500 lbs.; shipping measurements, 80 cu. ft.

DIVING OUTFIT No. 2.

Complete in all respects for one diver.

1 air pump, No. 4, single cylinder, double action, ash chest, iron brake, made in sections, for packing inside pump chest, strong brass handles for lashing................	$125.00
The equipment furnished and packed in this pump is as follows: 1 oil can. 1 10-inch monkey wrench.	
1 improved diving helmet, 3 lights, sectional screw to receive air in the head-piece, or one to receive air in the breast-plate, either style, with safety valve, adjustable regulating valve and recessed gasket seat............	100.00
1 rubber diving dress, No. 2 size.......................	50.00
100 feet standard white air hose (two pieces) with couplings, at 40c..	40.00
1 set diving weights, belt pattern......................	22.00
1 pair shoes, with lead or iron soles....................	15.00
1 pair rubber diving mittens...........................	5.00
1 pair rings and clamps...............................	5.00
1 life or signal line (125 feet).........................	2.25

1 pair cuff expanders	$ 5.00
1 diver's knife, belt and air hose holder	10.00
2 feet snap tubing, at 60c	1.20
1 pair chafing pants	4.00
1 pair diver's stockings	1.25
1 woolen shirt and drawers, at $1.50	3.00
1 pair woolen mittens	1.25
1 woolen cap	1.25
1 basket for helmet, dress, hose, etc	18.00
1 helmet cushion	3.00
3 bolts and nuts for helmet (spare), at 25c	1.50
½ yard rubber cloth for repairs	1.25
1 can rubber cement for repairs (1 lb.)	.75
1 cutting punch	.75
	$416.45

Net weight, 360 lbs.; gross weight, 475 lbs.; shipping measurements, 27 cu. ft.

SELECTION OF DIVING APPARATUS.

In the selection of an outfit the following points should be given careful consideration:

1. Duration of the work.
2. Whether it is to be conducted with long or short spaces of time intervening.
3. Depth of water.
4. Whether the outfit is to be used on rocky or sandy bottom.
5. Character of the work.
6. Selection of the pump.

The selection of the pump is the most important point, and in view of recent experiments and tests of the work that can be accomplished by a diver at different depths, buyers are apt to order pumps of too small capacity. A volume of air equal to that ordinarily breathed at the surface (about 1½ cubic feet per minute) should be introduced into the helmet. The volume of free air that must be taken in by the pump at the surface to deliver 1½ cubic feet per minute at 5 fathoms is about 3 cubic feet; at 16 fathoms, about 6 cubic feet; at 27 fathoms, about 9 cubic feet, etc.

The following table gives pressure in pounds per square inch at a given depth of water:

30 feet,	12¾	pounds.
60 feet,	26¼	pounds.
90 feet,	39	pounds.
120 feet,	52¼	pounds.
150 feet,	65¼	pounds (usual limit).
180 feet,	78	pounds.
210 feet,	91¼	pounds.
240 feet,	104	pounds.

DRAWING BOARDS

Drawing boards of thoroughly seasoned, selected narrow strips of white pine, and either finished natural or with a light coat of shellac, cost as follows:

One face for drawing.............	12 x 17"	$0.55
One face for drawing.............	16 x 21"	.80
One face for drawing.............	20 x 26"	1.05
Both faces for drawing............	12 x 17"	.55
Both faces for drawing............	16 x 21"	.88
Both faces for drawing............	20 x 26"	1.05
Both faces for drawing............	23 x 31"	1.45
Both faces for drawing............	27 x 34"	2.40
Both faces for drawing............	31 x 42"	3.20

Drawing boards of white pine, with hardwood ledges attached by screws, arranged to allow for contraction and expansion:

One face for drawing..............	16 x 21"	$1.20
One face for drawing..............	20 x 26"	1.75
One face for drawing..............	23 x 31"	2.60
One face for drawing..............	31 x 42"	4.20
One face for drawing..............	33 x 55"	6.80
One face for drawing..............	36 x 60"	8.00

Extra large drawing boards of pine:

36 x 72"	$12.80
36 x 84"	14.40
42 x 60"	12.00
42 x 72"	14.40
42 x 84"	16.80
42 x 96"	20.80
48 x 72"	19.20
48 x 96"	26.40
48 x 120"	35.20
54 x 96"	32.80
54 x 120"	40.00
60 x 96"	37.50
60 x 120"	46.50

Trestles and horses for drawing boards. Wooden horses, light construction, 37" high, 35" long, per pair, $2.60.

Ditto, fine quality, 37" high, 35" long, per pair, $4.40.

Ditto, fine quality, with removable sloping ledges, 37" high, 35" long, per pair, $4.80.

Adjustable wooden horses, best workmanship, 36" long, adjustable for height from 37" to 47" on level or slope, per pair $6.00.

Folding hardwood trestle, 37" high, with drawing board, 31 x 42", each, $12.80.

Ditto, 33 x 55", each, $16.00.

Adjustable drawing table with iron supports:

Board, 31 x 42" each................................	$21.00
Board, 33 x 55" each................................	23.00
Board, 36 x 60" each................................	24.50
Board, 42 x 72" each................................	28.50

DREDGES

There are four types of dredges: (1) The dipper dredge; (2) the grapple dredge; (3) the bucket elevator dredge; (4) the hydraulic dredge. For harbor work or where the water is rough the scow containing the machinery also has pockets for the material, which it conveys to sea or some other dumping place. This is called a hopper dredge.

DIPPER DREDGES

A dipper dredge is really a long-handled steam shovel mounted on a scow. The dippers range in size from ⅓ to 15 cu. yds. This type of dredge is adapted to work in all kinds of materials.

Mr. Gillette, in Earthwork, describes a home-made dipper dredge, the cost of which was as follows:

1	Hoisting engine and boiler (single drum, dbl. cyl., 8 H. P., 4¾ x 6 ins.; weight 3,500 lbs)	$ 500.00
2	Scows, 3,200 ft. B. M. (6 x 34 ft.)	150.00
10	Sheaves, 6 in.	20.00
120	Ft. 7/16 in. hoisting chain, 250 lbs., @ 8c	20.00
160	Ft. ¾ in. iron, 250 lbs., @ 4c	10.00
1	Dipper ⅓ yd., 400 lbs., @ 10c	40.00
40	Ft. cast iron rack, 200 lbs., @ 10c	20.00
1	Turntable plate and rim, 100 lbs., @ 10c	10.00
100	Bolts, ¾ x 12 ins., 200 lbs., @ 5c	10.00
1,000	Ft. B. M. yellow pine	30.00
	Labor and sundries	190.00
		$1,000.00

This dredge can be loaded on two flat cars or four ordinary wagons. The crew consists of three men and the total cost of operation is about $8.00 per day. In digging a trench 18 ft. wide by 12 ft. deep the average capacity in 10 hours is 60 yards of hardpan or 175 yards of river gravel.

In *Engineering News* of October 30, 1902, is described a dipper dredge with a 2½ cu. yd. bucket which excavated in clay 20 ft. below the water, depositing the material in two scows, each having a drop pocket of 140 cu. yds. A tug boat towed the scow containing material to the dumping ground. The total cost of the outfit was $43,000. Six per cent interest plus 6 per cent depreciation over 100 working days gives a cost of $51.60 per day. The usual rental of such a plant is $100.00 per day. The daily wages and coal bill average about $30.00. The average output in 10 hours was 745 cu. yds. at a total cost of 11c per cu. yd.

COST OF BUILDING A 2½ CU. YD. DIPPER DREDGE AND ITS FIRST SEASON'S WORK.

The following notes on the cost of dredging were abstracted from a report by B. F. Powell, engineer for the Fort Lyon Coal Co. at Las Animas, Colo., and appeared in *Engineering and Contracting* for May 29, 1912. The company, previous to 1911, had

let all its excavation work by contract, but after an investigation it decided to purchase a dredge and do its own excavating, Accordingly a contract was let to the Marion Steam Shovel Co. for a 2½ cu. yd. dipper dredge, with an 80-ft. boom. It was estimated that the probable cost of the dredge, with boat, etc., equipped and ready for operation, would be $26,000. It was estimated that the work could be done at a cost of operation not exceeding 4 cents per cubic yard, while the low bid received for the work was 8¾ cents per cubic yard. The difference on 1,000,000 cubic yards to be excavated would thus be a saving of $47,000. Out of this the dredge would be paid for and leave a balance of $20,000, and the machine would be had for future work.

The dredge was built under the supervision of the Marion Steam Shovel Co. Work on it was commenced April 3 and the hull was completed and launched on May 26, 1911. The boilers were steamed up on June 5 and used from that time on to furnish power for erecting the balance of the machinery. The fifteen-day test was begun on July 1, when it was demonstrated that the dredge would excavate its estimated yardage.

The hull of the dredge is 100 x 41 x 8 ft. and required 135,000 ft. B. M. of lumber. It has two 120 H. P. boilers, one double 10 x 12-in. hoisting engine, a double 8 x 10-in. swinging engine, an 80-ft. boom and a 2½ cu. yd. bucket. The amount of work accomplished by the dredge in the soft material in which it worked is given below:

	Cu. Yds.
July	74,000
August and September	130,000
October	71,750
Total	275,750

The cost of operation as given for the month of October was $0.0315 per cubic yard.

The dimensions of the irrigating and storage canal now being completed are 120 feet on top and 100 feet on the bottom for the first two miles from the head gate; for the next mile the width is 20 feet less, and after the third mile the width is again reduced 20 feet, making the bottom width 60 feet, with 1:1 slopes. The depth is 10 feet.

The actual cost of the dredge follows:

COST OF DREDGE.

Materials:	
Dredge equipment	$14,932.00
Extra boiler	1,600.00
Electric light plant	500.00
Freight	413.96
Tools	250.00
Extra machinery	571.17
Boiler flues	236.80
Oakum	4.50
Steel and castings	427.70
Wire rope	510.75
Oil	317.27

COST OF DREDGE—Continued

Coal and hauling	$ 2,896.68
Hardware	1,880.22
Groceries and camp supplies	1,611.45
Lumber	5,033.27
Total	$31,185.77
Labor:	
Constructor	$ 584.70
Foreman	984.92
Cook	155.00
Dredge runner	722.83
Labor	1,717.03
Carpenters	1,232.05
Hauling	404.45
Sundry expenses, materials, teams, labor	2,818.33
Total	$ 8,619.33
Total, labor and material	$39,804.08

The above table shows the cost of the dredge, its construction and its operation until the end of the season, November 11, 1911, as shown by the company's books. If we multiply the yardage excavated by about 4 cents (the cost of operation) and deduct this amount, $11,030, from the total shown in the table, the result should give the cost of the dredge ready for operation. This is $28,774.

The following data were abstracted from an article by Mr. C. W. Durham in Professional Memoirs, and reprinted in *Engineering and Contracting*, July 17, 1912:

The equipment includes three dipper dredges, Ajax, Vulcan and Phoenix, and two pipe-line dredges, Geyser and Hecla. As will be noted, the care and upkeep of dredges are very expensive, and in the case of suction dredges the pontoons and catamarans also require much repair.

The Ajax has hull dimensions 70 x 26 x 6 feet; she was rebuilt in 1894 and, with large annual miscellaneous repairs, has been kept in good condition.

The Vulcan, oak hull, 80 x 30 x 8 feet; nominal repairs to 1890; hull rebuilt in 1892-1893 and 1898-1909; condition now good, although annual repairs have been large for the past eight years.

The Phoenix, oak hull, 80 x 8 feet; nominal repairs to 1890; hull rebuilt in 1895-1896; burned and entirely rebuilt, using a portion of the old machinery, in 1908-1909, at a cost of $19,581.29; now in good condition.

The Geyser, with eleven pontoons, was built by the United States at small cost, using an old boiler and pump; hull pine, 100 x 20 x 4 feet; pump, 12-in. suction; large expenditures each year for pump, pipe pontoons, etc., in addition to hull repairs; condition bad.

The Hecla, 15-in. suction dredge, with eleven pontoons; built by United States; large repairs every year; hull fir and oak, 120 x 26 x 5 feet; rebuilt 1909-1910; good condition.

TABLE 94—COST AND REPAIRS OF DREDGES.

	Year.	Dipper dredge Ajax, bought 1877; built 1876. (Oak hull.)	Dipper dredge Vulcan, built 1882-1883. (Oak hull.)	Dipper dredge Phoenix, built 1885. (Oak hull.)	Suction dredge Geyser, built 1893. (Fir hull.)	Suction dredge Hecla, built 1900-1901. (Fir hull.)
Original cost.......	....	$11,300.00	$19,450.00	$19,525.00	$ 4,704.44	$27,708.66
Repairs to and inc.	1890	....	2,840.82	2,848.27	....	....
Repairs	1891	....	....	199.28	....	....
Repairs	1892	†11,539.60	*1,525.61	797.78	....	....
Repairs	1893	536.03	*3,373.06	766.71	....	....
Repairs	1894	*5,801.75	27.92	391.34	2,032.36	....
Repairs	1895	1,494.86	1,337.78	*1,582.93	1,661.20	....
Repairs	1896	713.00	1,904.42	*3,033.18	639.33	....
Repairs	1897	1,177.85	903.49	806.32	1,299.48	....
Repairs	1898	423.26	*2,256.89	1,166.02	1,462.74	....
Repairs	1899	1,079.07	*3,887.66	1,123.26	1,344.31	....
Repairs	1900	1,029.55	614.45	1,360.17	1,646.45	....
Repairs	1901	490.69	349.59	931.50	1,177.04	....
Repairs	1902	747.92	822.36	889.86	1,266.11	1,081.41
Repairs	1903	1,425.36	1,530.67	306.70	1,905.00	3,405.09
Repairs	1904	449.03	2,223.93	999.13	1,040.71	3,395.78
Repairs	1905	709.33	1,955.35	903.92	2,793.23	3,650.24
Repairs	1906	2,646.86	2,546.13	1,396.33	2,171.35	1,677.00
Repairs	1907	1,709.79	1,745.82	1,818.27	1,960.88	2,681.56
Repairs	1908	1,210.24	2,837.16	‡7,859.91	3,512.48	1,044.20
Repairs	1909	1,829.54	2,986.84	‡11,721.38	2,713.74	2,692.51
Repairs	1910	1,788.47	1,996.41	1,674.71	2,897.12	1,421.59
Totals to date..		$48,102.20	$57,116.36	$62,101.97	$36.227.97	$48,758.04

* New hull, etc. † Repairs to Dec. 31, 1892. ‡ Burnt and rebuilt

SOME COSTS OF DREDGEWORK ON THE LOS ANGELES AQUEDUCT.

The following costs of dredging are taken from the monthly report for February, 1911, on a section of the Los Angeles aqueduct through the Owens Valley. The dredge consists of a scow on which is mounted a No. 60 Marion electric shovel with a 1½ cu. yd. dipper. The cost of the dredge was $19,897, and it was built according to the specifications of the aqueduct engineers. The yardage is based upon the theoretical section of the aqueduct, or 14.81 cu. yds. per lineal foot. This is exceeded to a small extent by excess cutting. The following are the data for February:

	Teams and men.	Operation.	Renewals and rep.	Misc.	Totals.
Men, No. of days...	10	205	241	3	459
Live stock, No. of days	....	56	12	....	......
Lineal feet	....	2,625	......	....	......
Cubic yards	....	38,876	......	....	......
Labor costs	$34.29	$ 727.39	$ 838.81	$17.85	$1,618.34
Live stock costs....	....	50.40	10.80	....	61.20
Cost materials and supplies	....	1.75	120.32	....	122.07
Power cost	....	408.51	9.79	....	418.30
Freight cost	....	.35	24.06	....	24.41
Total costs	$34.29	$1,188.40	$1,003.78	$17.85	$2,244.32
Unit cost per cubic yard....	$0.0001	$0.0306	$0.0258	....	$0.0565

The unit cost per cubic yard for the month figures 5.65 cents, but the unit cost given for the work of the dredge to date is 6.7 cents.

GRAPPLE DREDGE.

Grapple or grab bucket dredges are also known as clamshell or orange peel dredges, according to the type of bucket used in excavating. They are adapted to work in very deep water or in confined places, such as caissons.

In *Engineering News*, February 2, 1899, an Osgood 10 cu. yd. clamshell dredge is described. The crew consisted of ten men, and five tons of coal were consumed in ten hours. The machine had a capacity of one bucket load per minute and averaged about 400 cu. yds. per day.

The table on page 216 has been compiled from the report of Gen. Bixby, Chief of Engineers of U. S. A., for the fiscal year of the U. S. Government ending June 30, 1911, and contains some important data. The column headed "Total Cost of Dredging" is understood to include cost of repairs, but not interest and depreciation. The oldest of these dredges seems to have been built in 1869, which would make its age at the time of the report 42 years. It is hardly safe, however, to

consider this the standard age for computing depreciation. At the age of 30 a dredge is either so antiquated as to make repairs very heavy, or so out of date as to make it uneconomical to operate. Therefore, fixing 30 years as the life, which is more than that of the average locomotive in the United States, and allowing interest at 6 per cent, the annual interest and depreciation on the total cost of the dredges would be $82,061, or about 2c per cu. yd. in addition to the average figure of 13.6c given in the table.

A clam shell dredge, Delta (Fig. 81), was used by the California Development Co. from November, 1906, to the present time (1912) in places where it was necessary to build up levees to greater heights than could be reached by the dipper dredges. The following description is compiled from a paper by Mr. H. T. Corry, Trans. Am. Soc. C. E., November, 1912:

The dredge had a hull 120 ft. long, 54 ft. wide, and 11 ft. deep, and was equipped with a clamshell bucket mounted on a 150 ft. boom. The machinery comprised a 150 H. P. internally fired, circular, fire-tube boiler, and a 20 x 24-in. engine on each side. Work on the hull was started May 1, the hull launched August 15, and the machinery in place at the end of October. The total cost of the dredge was $80,000, including $34,000 for machinery f. o. b. San Francisco. The weight of the craft was 850 tons.

Operatives:

1 captain at $125 to $150 per month and board.
3 levermen at $85 per month and board.
2 firemen at $60 per month and board.
2 deckhands at $50 per month and board.
1 cook at $50 per month and board.
1 blacksmith at $90 per month and board.
1 roustabout at $40 per month and board.

Three shifts were worked, making a total of 22 hours actual work per day. The average time in operation was 28 days per month. In good ground, with side swings averaging 70 degrees on each side, the time per bucketful was 40 seconds. The quantity handled varied with the kind of material from 3 to 8 cu. yds. extremes. On the Sacramento River, under good conditions, 150,000 cu. yds. per month were handled.

Monthly expenses:

Maintenance and operation	$2,500.00
Interest on investment at 6 per cent	400.00
Taxes and insurance	200.00
Deterioration	700.00
	$3,800.00

The foregoing "monthly expense" is a minimum; ordinarily, in Mexico, the monthly expense was $5,000. The average cost in Mexico was 4 to 6 cents per cubic yard.

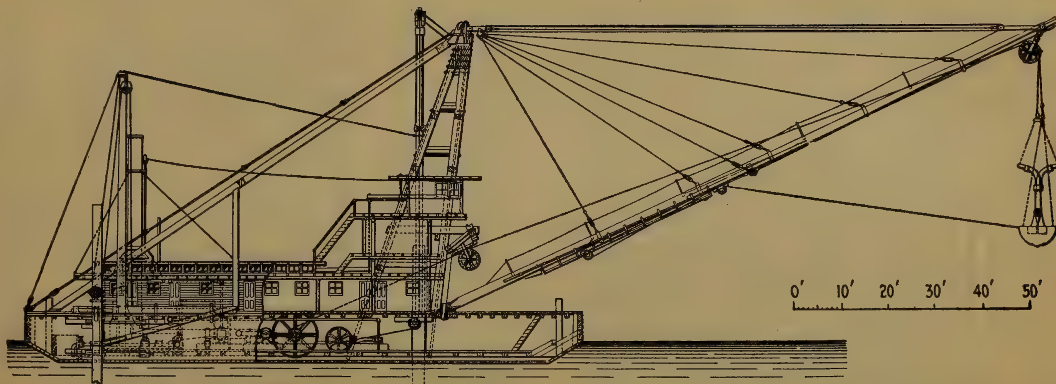

Fig. 81. Clam Shell Dredge "Delta" of California Development Co.

LADDER DREDGE.

Bucket elevator dredges are known as bucket ladder dredges, chain bucket dredges or endless bucket dredges. They are used principally abroad, and in the United States mainly on canal work. They are very good where the cutting is light and also in finished work, for they leave a smooth bottom.

In Trans. A. S. of M. E., 1886-7, Mr. A. M. Robinson says that 1 H. P. on an elevator dredge will excavate 5 to 9 cu. yds. whereas in a dipper dredge 1 H. P. will excavate about 3¾ cu. yds. in 32 ft. of water.

In *Engineering News*, August 4, 1892, a Bucyrus bucket elevator dredge is described. The average daily output was 1,180 yards in 10 hours in soft sponge material. The crew consisted of six men and the cost of excavation per cu. yd. was about 3c.

In a paper read before the Institute of Mining and Metallurgy of Great Britain on April 19, 1906, Mr. E. Seaborn Marks and Mr. Gerald N. Marks gave descriptions of bucket dredges used for dredging gold in Australia. A total of 50,000 to 70,000 sup. ft. of timber are used in building a pontoon which will measure from 70 to 90 ft. or more in length, about 30 ft. in width and 6 ft. 6 in. in depth. These dimensions vary with the weight of machinery and the general arrangement and design of the plant. Australian hard woods are excellent material, on account of their strength and durability, but their weight is an objection should a shallow draft be required. In this case Oregon pine would be preferable for planking, with hard wood framing. If hard wood is not procurable, pitch pine should be used for framing, as Oregon does not hold spikes securely. All pontoons are coated with tar to preserve the timber, after the seams have been calked, and are plated with ⅛-in. steel plate for 6 ft. at either end as a protection from sunken logs. In countries where transportation is difficult and skilled labor scarce, pontoons are constructed of steel plates and girders. These are built in the works and afterwards taken to pieces and shipped in sections. The cost of building three plants and pontoons is given below, but these prices will necessarily vary with the cost of transporting, labor and such items:

(1) A pontoon of hard wood with an inner skin of Oregon pine cost $5,760. The complete plant cost $32,500. This machine is a screen dredge with a discharge into a sluice run. A similar plant with a tailings elevator (in which case the screen would be lowered to within a few feet of the deck and power thereby saved in pumping up the water for washing purposes) would cost approximately $5,000 more.

(2) The pontoon constructed of Oregon planking spiked to hardwood framing of cheap and effective design cost $4,140. The complete plant cost $27,500. The frame has diagonal struts forward, on the lower one of which the frame is pivoted and can be moved up and down to alter the dredging depth.

(3) A pontoon, built on somewhat different lines with diagonal and cross braces, is constructed of Oregon planking with hard wood frames and is suitable for working light, shallow grounds. The gantry from which the ladder is swung is constructed of steel in the first two pontoons but in this case it is of Oregon pine. This dredge has a combination of sluice box, screen and elevator and can be lengthened so as to do the combined work of a screen and tailings elevator. The cost of the plant complete was $30,000. The buckets in general use were of 4½ cu. ft. capacity of 5-16 to ½ in. steel. They varied, however, from 3 to 12 cu. ft. capacity. The boiler generally used is of the return tube marine type with internal flue working up to 120 lbs. per sq. in. It is usually 6 ft. 6 in. in diameter and 8 ft. long (12 ft. over all with combustion chamber and smoke box), fitted with 48 tubes and will give 75 I. H. P. The engine is from 16 to 25 H. P., making 125 revolutions per minute. The 16 H. P. one has compound cylinders 8 x 14½ and 14 x 14½ ins. A belt from the fly wheel connects with the first motion shaft, and the pulley works a 12 in. centrifugal pump.

The following table is the result of two dredges used in dredging gold.

	No. 1 Dredge.	No. 2 Dredge.
Full working time for a year	52 wks. or 7,488 hrs. in each case.	
Actual time worked	6,161 hrs.	5,572 hrs.
Percentage of lost time	17.70%	25.6%
Gross capacity of dredge	130 cu. yds. per hr.	112.5 cu yds. per hr.
Material actually treated	325,896.3 cu. yds.	303,360 cu. yds.
*Percentage of material treated relatively to gross capacity for time worked	40.6%	48%
Gold recovered	1,198 oz. 12 dwt.	1,393 oz. 17 dwt. 22 gr.
Net value	£4,815 19s 2d	£5,103 18s 1d
Total working expense	£3,321 18s 8d	£4,149 16s 7d
Net profit	£1,494 0s 6d	£1,954 1s 6d
Value per cu. yd. of material treated	1.76 gr. or 3.5d	2.2 gr. or 4d
Cost of treatment per cu. yd.	2.4d	2.4d

*Calculated in each case with 4½ cu. ft. buckets, but in the first 13 buckets and in the second 11.25 buckets per minute were delivered.

The following table gives the expenditures during the week ending Aug. 17, 1905:

	No. 1 Dredge. £.	s.	d.	No. 2 Dredge. £.	s.	d.
Wages	30	17	1.2	30	15	11.2
Repairs and renewals	10	15	4.4	6	10	1.7
Fuel	8	17	7.4	5	15	11.9
General expenses	0	15	2.5	1	5	10.5
Traveling expenses	0	3	3.8	0	2	3.5
Rent on leases	0	10	8.9	3	19	9.7
Freight and cartage	1	0	7.2	1	1	2.0
Insurance	0	11	7.5	0	15	2.3
Dredge supplies	0	16	1.8	0	14	4.2
Office and management	9	9	10.5	9	10	8.7
	63	17	7.2	60	11	5.7

A bucket ladder dredge and special conveyor were built at Adams Basin on the New York Barge Canal during the summer of 1909.

The dredge itself is floated on two steel pontoons which are parallel to each other and are braced together by a rigid framework. A gantry projects in front of and between the pontoons and supports the ladder, which extends to the bottom of the canal. The buckets each have a capacity of 5 cu. ft. From a hopper at the top of the ladder the material is discharged upon a belt which in turn discharges into a second hopper and a second belt at the rear of the dredge. A third belt is carried on a separate pontoon, along a steel cantilever frame which carries the belt 40 or 50 ft. to the bank. Each belt is operated by a separate motor receiving power from the dredge. The plant cost $70,000.

The cost of the work for the first three months was as follows:

August, 1909; 18,638 cu. yds. excavated:

Coal and oil	$1,984.50
Fifteen tons coal for hoisting engine, at $2.85	42.75
Miscellaneous supplies for hoisting engine	5.25
Miscellaneous supplies for hoisting engine and derrick	6.48
Hauling supplies	54.00
Crew of dredge	2,296.68
Total cost	$4,389.66

Cost per cu. yd., 23.6 cents.

Interest and depreciation, etc., were not to be included, on account of commencing work in this month.

Drains and scrapers supplemented the dredge, moving 6,244 yds. for a total of $1,280.50, or 20.5 cts. per cu. yd. The cost of wooden forms and of spreading and compacting amounted to $1,193.25 for 10,015 cu. yds. of embankment, or 11.9 cts. per cu. yd.

September, 1909; 32,000 cu. yds. excavated:

Interest, dep. and repairs	$2,205.00
180 tons coal, at (2 tons per shift)	513.00
150 gals. gasoline at 12 cts.	18.00
Oil (80 gals. at 19 cts.; 60 gals. at 35 cts)	36.20
1,200 lbs. grease at 8 cts	96.00
200 lbs. waste at 8 cts	16.00
Teams	245.00
Labor	2,827.00
Total cost	$5,956.20

Cost per cubic yard, 18.6 cents.

A total of 90 eight-hour shifts were worked. The cost of the embankment was as follows:

Labor, spreading and compacting	$3,151.50
Hauling form lumber	177.16
Cost form lumber	1,125.00
General	290.00
Labor on forms	828.32
Hauling supplies	55.00
Total	$5,626.98

Only 11,000 cu. yds. were allowed for the above work on embankment, as the forms gave way and the soft material had to be scraped back. This brought the cost of embankment for the month up to 51.1 cts. per yd.

October, 1909; 25,500 cu. yds. excavated:

Interest and depreciation	$2,351.66
186 tons coal at $2.85	530.10
Labor $	3,145.58
Teams	5.00
Oil, grease and waste	153.09
Gasoline	18.60
Repairs	18.90
Total cost	$6,222.93

Cost per cubic yard, 24.4 cents

A total of 93 eight-hour shifts were worked. The cost of embankment was as follows:

Labor, spreading and compacting	$2,898.25
Forms	567.50
Erection	108.50
Hauling	95.00
Total	$3,669.25

This gives for 21,800 cu. yds. of embankment a cost of 16.9 cts. per cu. yd.

RECENT EXAMPLES OF CALIFORNIA GOLD DREDGES WITH COSTS OF DREDGING.

A concise statement of practice in California in dredge construction for reclaiming gold from underwater gravels is taken from an elaborate paper by Mr. Charles Janin in the bulletin for March, 1912, of the American Institute of Mining Engineers. The paper also gives a table of costs which are of general interest in view of the increasing favor with which elevator dredges are being considered in America.

The modern California type dredge, with close-connected buckets, spuds and belt conveyor for stacking tailings, was a gradual development through years of experimenting. This dredge embodies the ideas of successful operators, and it is generally conceded that dredge construction and operating methods in California are far ahead of those in any other country in the world. The dredges built in California cost from $25,000 to $265,000 each; a standard 8.5 cu. ft. boat costing from $150,000 to $175,000, according to conditions to be met in operation. With great improvements made in dredge construction, and corresponding reduction in operating costs, areas that were at first considered too low grade to be equipped with a dredge are being profitably worked.

California dredges vary in size from 3.5 to 15 cu. ft. buckets.

In Alaska some dredges are equipped with buckets as small as 1.25 cu. ft. to dig shallow ground, and are reported to be

working profitably. While electricity is the ideal power for operating dredges, steam has been successfully used on a number of installations, and experience has proved the merits of the gasoline and distillate engine for this work. There seems little doubt but that the successful development of the gas producer for the generating of electric power will prove an important factor in considering future dredging of gravel areas in districts where electric power or water power for the installation of hydro-electric plants is not at present available.

One of the largest gold dredges operating in California was put in commission at Hammonton, in Yuba River basin, August 10, 1911. This dredge was built by the Yuba Construction Co. and is one of five practically similar dredges built by the same company this year. It required 820,000 ft. of lumber for the hull and housing the hull; its dimensions are 150 x 58.5 x 12.5 ft., with an overhang of 5 ft. on each side, making 68.5 ft. total width of housing. The digging ladder is of plate girder construction and designed to dig 65 ft. below water level, and is equipped with ninety 15 cu. ft. buckets arranged in a close connected line. The entire weight of the digging ladder and bucket line is approximately 700,000 lbs. The washing screen is of the revolving type, roller driven, and is 9 ft. in diameter by 50.5 ft. long and weighs 111,721 lbs. Two steel spuds are used, each weighing over 44 tons. The ladder hoist winch has a double drum and weighs 67,016 lbs. The swinging winch consists of eight drums and weighs 34,193 lbs. The stacker hoist winch weighs 3,732 lbs. The gold saving tables are of the double bank type and have an approximate riffle area of 8,000 sq. ft. The tailings sluices at the stern can be arranged to discharge the sand from the tables either close to the dredge or at some distance behind. The conveyor stacker belt is 42 in. wide and 275 ft. long, on a stacker ladder of the lattice girder type, 142 ft. long. Nine motors are in use on the dredge with a total rated capacity of 1,072 h. p. The total weight of hull and equipment is 4,640,862 lbs.

Natoma No. 10 dredge, now under construction, is equipped with 15 cu. ft. buckets, and will have a steel hull, being the first dredge operating on a steel hull in California. The hull will be 150 x 56 x 10.5 ft. and will have a total weight of 920,000 lbs. This will be about one-half the weight of a wooden hull to carry the same machinery, and the draft of the boat will be considerably lighter. This boat will be in operation in April, 1912.

The machinery of some California dredges has been dismantled and moved to other fields and installed on new dredges. The estimated cost of dismantling the Scott River dredge, which was equipped with 7.5 cu. ft. buckets, building a new hull, installing machinery, including a 28-mile haul, with a freight cost of over 1 cent per pound and building a 5-mile transmission line, was $80,000. The Butte dredge was put in operation in November, 1902, and dismantled in July, 1910. It was equipped with 3.5

cu. ft. buckets. The machinery is being placed on a new hull and includes a new bucket line of 4 cu. ft. buckets. The cost of the installation has been estimated at $30,000.

The dipper dredge has been successfully operated on small areas at Oroville and elsewhere, but does not meet with approval among dredge operators in general, who contend that the efficiency of these boats, both as to yardage and gold saving capacity, is not up to that of the standard type. These boats have a low first cost (about $25,000, f. o. b. factory) and are built with buckets of from 1.25 to 2.5 cu. yds. capacity. It is claimed by the dealers and some operators that under the following conditions there is a field for this type of dredge: (1) Where the ground is somewhat shallow; (2) where the extent of the ground is not sufficient to warrant the installation of a costly dredge; (3) where the material is of a rough character, boulders and stumps; (4) where the ground is mixed with more or less clay, as the dipper will relieve itself notwithstanding the adhesiveness of the material.

What seems to be a record in dredge construction is the building of the dredge for the Julian Gold Mining & Dredging Co. on Osbourn creek, near Nome, Alaska. This dredge was constructed by the Union Construction Co. of San Francisco. The dredge was shipped from San Francisco on June 1, arriving at Nome June 13. On June 17 the company commenced hauling material, and on July 22 the dredge was completed and operations started. The dredge hull is 30x60x6.5 ft. It is equipped with 34 open connected 2.75 cu. ft. buckets, and is designed to dig 14 ft. below water level. Power is furnished by gasoline engines as follows: One 50 h. p. for digging ladder, winches and screen; one 30 h. p. for pump; one 7 h. p. for lighting apparatus; a total of 87 h. p. Distillate costs at Nome 21 cents per gallon. Operating expenses at present range from $110 to $125 per day, and the capacity of the dredge is from 1,000 to 1,300 cu. yds. per day, indicating an operating cost of from 10 to 11 cents per cubic yard, exclusive of repairs. The cost of the dredge complete and in operation was $45,000.

The operating cost of dredging is always a matter of interest, but working costs cannot be fairly used in comparison unless uniform methods of determining them are employed, and also unless operating conditions are somewhat similar. As in other branches of the mining industry, it may also be said that the apparent operating cost is in a great measure a matter of bookkeeping. It is interesting to note the following average operating cost per cubic yard of the large companies working in California during 1910. The Yuba Construction Co., for the year ended February 28, 1911, handled 13,970,728 cu. yds. at a total cost of 5.67 cents per cubic yard. The Natomas Consolidated handled, for the year ended December 31, 1910, a total of 15,989,525 cu. yds. at a total cost of 4.52 cents per cubic yard, and during the six months ended June 30, 1911, a total of 10,-793,891 cu. yds. at a total operating cost of 3.78 cents per cubic

yard. This company has put in commission during 1912 three dredges with buckets having a capacity of 15 cu. ft. These two boats are now satisfactorily handling ground that for a long time was considered too difficult for economical dredging. The gravel is deeper and more compact than any other in the district, and dredge No. 8 is handling ground containing much stiff clay. The Oroville Dredging, Ltd., for the year ended July 31, 1910, handled 5,661,612 cu. yds. at a total cost of 5.05 cents per cubic yard.

TABLE 94A—SHOWING OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE ENGINEER DEPARTMENT AT LARGE, U. S. ARMY. FOR THE FISCAL YEAR ENDING JUNE 30, 1911.

CLASS C.—BUCKET AND DIPPER DREDGES.

Dredge	When Built Year	Contract Cost and Outfit Dollars	Dimens'ns of Hull Length Beam Depth Feet	Bucket Type	Bucket Capacity C.YD.	Length of Boom	Dimensions of Main Hoisting Engine Cylinders Inches	No.	Type Boilers	Diameter in.	Length ft.	h.p.	Steam Pressure lbs.	Crew men	Dredging Capacity per Hour c.yd.	Character of Dredged Material	Material Dredged During Year 1910-11 Yds.	Total Cost of Dredging Dollars	Total Cost per Cubic Yard Cents	Cost of Repairs Doll's
Addison	'80	14,000	75x30x7	D	1½	31	9x18	1	L	54	15½	60	90	6	24	G, Sd, St......*	15,306	3,721	24.3	115
Alabama	'91	22,300	80x38x6	CB	5-c.f.	None	10x14	1	M	60	17	40	90	7	213	SM,G ....*	137,088	6,888	5.0	1,921
Albany	'08	11,731	70x30x5	OP	1	60	8¼x10	1	U	50	10	30	100	7	50	BR ....*	18,531	4,433	23.9	342
Attalla	'02	17,000	75x26x6	TD	1¼	28	8¼x10	1	I	78	12½	60	160	7	60	Sd, G, BR.....*	12,000	4,866	40.5	232
Autauga	'02	13,440	75x26x6	TD	1½	30	8x10	1	L	48	14½	45	100	9	120	Sd, G, Ml......*	25,464	2,895	11.4	499
Carrollton	'01	22,272	80x30x7	D	2½	40	10x14	1	T	54	16	70	110	9	90	Sd, G, Md......†	40,610	4,168	10.3	438
Frankfort	'08	10,193	72x19x5	D	¾	27	8x10	1	FbT	50	15	40	125	9	50	Sd, G, Md.....†	37,815	7,139	18.9	282
Green River	'96	4,094	112x31x4	D	1¼	50	8x12	1	L	48	14	61	150	8	50	Md, L, Sd, St..*	36,118	4,736	13.1	340
Kentucky	'00	34,300	100x34x7	D	2-4	45	12x16	1	L	66	20	100	100	10	175	LG ....†	292,800	14,617	5.0	1,382
Kwasind	'99	11,000	80x28x7	D	1½	38	9x10	1	L	42	15	40	120	8	87	HP, R.........†	40,465	5,996	14.8	5,202
Sapelo	'94	12,000	85x31x5	OP	¾	56	7x10	1	VT	48	8	45	100	10	40	Sd, C.........†	13,500	12,000	90.8	400
Tennessee	'10	37,513	100x34x7	D	1½-2	45	10x14	1	L	66	20	100	125	10	150	G, R..........†	160,300	22,687	14.0	1,550
Upatoi	'01	15,718	85x30x6	D	2	35	10½x12	2	L {	40 54	17 18 }	135	100	10	125	Sd, G, R.......*	58,335	7,900	13.5	899
Wolf	'97	8,000	80x28x5	D	1	40	9½x10	1	L	44	16	40	100	6	40	Sd ....†	12,100	2,227	18.4	3,048
No. 1 D. B.	'08	8,800	65x27x6	C	1½	43	10x12	1	U	53	8½	50	100	15	60	Sd, G.........†	50,575	8,589	17.0	2,095
Dredge No. 1	'03	18,950	80x30x7	D	1½	45	8x12	1	L	42	12½	40	100	5	75	Sd, G ....†	14,470	1,013	7.0	250
No. 19	'06	4,500	76x25x7	C	1	45	8¼x10	1	FT	43	8	30	125	5	40	Md, R ....†	1,700	400	24.0	70
Totals		$265,811															967,177	$114,275	11.8	
Ajax	'76	11,300	73x26x6	D	1½	30	8x18	1	UT	54	10	40	120	8	40	C, Md, R......*	35,987	6,864	19.1	1,402
Algoma	'72	29,500	79x30x7	D	2½	Mast	12x14	1	L	52	14½	40	90	8	105	Sd, Md, C, St..*	221,960	21,661	9.7	3,692
Apache	'95	15,255	80x30x8	D	2½	34	10x12	1	FB	54	17⅓	75	90	6	40	BR ....*	7,893	3,900	49.2	83
Appleton	'76	13,000	90x32x7	SD	2¼	39	12x26	1	L	54	13³/₄	86	90	6	70	C, Md, Sd, R...*	74,055	4,953	6.7	1,408
Farquhar Col.	'69	15,500	76x24x6	D	2	40	10⅜x12	1	M	60	10	..	80	8	65	Sd, C, G, Sh...†	45,171	7,263	16.1	1,667
Frontenac	'91	14,650	76x26x7	D	1½	26	8¼x10	1	L	48	15	53	100	8	50	Md, Sd, Si, G..†	48,810	7,423	15.2	475
Maumee	'94	30,000	100x36x11	D	3½	42	14x20	2	L	56	19	100	70	13	175	Md, B ....*	72,680	23,546	32.4	4,846
Omro	'78	5,500	100x30x6	G	2¼	60	8x12	1	SM	84	11	85	110	5	80	C, Md, Sd.....*	94,820	3,436	3.6	836
Oshkosh	'06	39,529	75x31x6	CB	5-c.f.	None	9x12	1	SM	108	10	140	125	9	200	C, Mk, Sd......*	135,775	8,146	6.0	3,880
Ottertail	'82	12,600	75x24x6	SB	1½	28	8x16	1	L	42	16	40	90	10	60	TC ....*	42,100	6,422	15.3	3,504
Phoenix	'85	19,525	80x30x8	D	2½	34	12x18	1	FB	60	15	75	125	6	70	R, G, C.......*	41,420	7,698	18.6	780
Vulcan	'83	19,450	80x30x8	D	2½	34	12x18	1	FB	60	17	75	106	6	100	R ....†	21,610	8,111	37.5	539
Dredge No. 2	'82	15,500	80x30x7	BD	1¼	34	12x14	1	L	54	19	125	90	5	100	Sd, C ....†	97,746	11,301	11.5	500
Totals		$241,309															940,027	$120,714	12.9	
Ajax	'84	16,500	82x33x10	CS	5	48	18x24	1	L	84	19	125	80	11	166	Sd, Md, C, Sp..*	542,027	28,476	5.3	....
Cheraw	'06	45,500	150x29x8	D	1¾	49	16½x18	2	RT	72	18	150	90	12	90	Md, Sd, Sp....*	98,122	12,083	12.3	3,415
Hercules	'07	64,646	100x38x11	CS	7	55	18x24	1	L	84	23	160	90	12	160	Sd, Md, C, Sp..*	566,631	34,117	6.0	....
Scuppernong	'04	10,300	78x32x7	CS	2½	43	7x12	1	L	62	20	100	75	11	36	Md, HP, R....*	81,628	13,098	15.8	1,145
Derrick A.	'07	6,000	80x28x4	OP	1¼	45	10x13	1	UT	48	8½	..	100	10	25	S ....*	3,180	1,251	39.3	21
Bank Derrick No. 1	'10	4,487	33x8-car	Gb	1	45	8x12	1	PF	46	8½	50	125	3	40	Sd, Md, Sp....*	27,004	3,355	12.4	....
Bank Derrick No. 2	'10	2,787	33x8-car	OP	¾	45	8¼x10	1	PF	40	9	25	100	3	35	Sd, Md, Sp....*	23,546	3,022	12.8	....
Totals		$150,120															1,342,138	$ 95,402	7.1	
Cascade	'06	6,056	60x30x5	OP	1	52	10x12	1	V	53	8½	50	90	8	59	Si ....*	34,160	5,309	15.5	1,387
Champoeg	'04	20,200	80x30x5	D	1	40	8x12	1	L	42	15⅓	40	90	10	60	G ....*	43,433	10,383	24.0	1,894
Cowlitz	'95	4,750	78x34x6	CS	1½	60	10x12	1	RT	84	12	80	90	10	75	Sd, G, C.......*	57,186	6,483	11.2	1,702
Totals		$31,006															134,779	$ 22,175	16.5	
Casey	'07	15,132	86x28x7	CS	2	42	11x18	1	L	60	..	80	100	5	200	Md, Cs ....*	68,950	5,093	7.4	787
Louisville	'86	25,000	67x28x6	D	2	30	12x14	1	L	54	..	60	100	6	90	Md, Cs, R.....*	42,375	5,502	13.0	1,015
Malta	'88	17,000	70x31x7	CB	3-c.f.	None	10x16	1	L	48	17	55	90	9	120	Sd, G, Md, R..*	91,763	13,913	15.2	2,053
Ohio	'73	35,000	110x32x7	D	2⁷/₁₀	24	12x15	1	RWT	..	..	150	120	14	250	G, Sd, B......*	109,579	22,102	20.2	2,211
Oswego	'83	35,000	92x32x6	D	2⁷/₁₀	24	12x15	1	RWT	..	..	120	120	12	250	G, Sd, B.......*	122,967	20,726	16.7	2,374
Totals		$127,132															435,634	$ 67,336	15.5	....
Hellgate	'69	25,000	10x35x12	CS	6	50	18½x24	1	ML	96	14	60	70	11	100	†	11,866	$ 16,033	135.0	1,549
Dredge No. 1	'03	17,565	85x32x6	D	2⅓	40	11x14	2	 LV	54 30	18 6	70	110	9	100	Md, LR ....†	84,850	28,822	33.9	886
Dredge No. 2	'05	21,600	87x30x5	D	1¾	35	10x14	2	 LV	54 36	18 7	75	100	9	67	†	115,614	26,152	22.6	1,287
Totals		$64,165															212,330	$ 71,007	27.4	....
Grand Totals		$879,543															4,032,085	490,909	12.2	....

* Includes repairs. † Operating cost only.

1. BUCKET TYPE. BD—Bottom Dump; C—Clamshell; CB—Chain Buckets; D—Dipper; G—Grapple; Gb—Grab; OP—Orange Peel; SB—Sliding Bottom; SD—Scoop Dipper; TD—Teeth Dipper.
2. BOILER TYPE. I—Internal; FB—Fire Box; FbT—Firebox Tubular; FT—Fire Tubular; L—Locomotive; M—Marine; ML—Marine Leg; PF—Plain Flue; RT—Return Tubular; RWT—Roberts W. T.; SM—Scotch Marine; T—Tubular; U—Upright; UT—Upright Tubular; V—Vertical; VT—Vertical Tube.
3. CHARACTER OF DREDGED MATERIAL. B—Boulders; BR—Blasted Rock; C—Clay; Cs—Cinders; G—Gravel; HP—Hard Pan; L—Leaves; LG—Loose Gravel; LR—Ledge Rock; Md—Mud; Mk—Muck; Ml—Marl; R—Rock; Sd—Sand; Sh—Shale; Si—Silt; SM—Soft Mud; Sp—Stumps; St—Stone; TC—Tenacious Clay.

TABLE 95—OPERATING COSTS OF CALIFORNIA GOLD DREDGES.

Capacity of buckets.	Time in commission.	Working period for figures given.	Actual working time; hours during working period.[1]	Quantity handled.	Average depth of gravel.	Labor and material.	Electric power.	Water.	Repairs.	General.	Taxes and insurance.	Total expense.	Remarks.
						Operating Expenses, in Cts. per Cu. Yd.							
Cu. ft.			Hrs.	Cu. yds.	Ft.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	
3	....	1 yr.	2,809	173,655	27.0	2.77	0.90	0.14	4.15	0.78	0.49	9.23	Difficult digging.[7]
3	5 yr. 9 mo.	1 yr.	7,216	458,882	26.9	2.03	0.69	...	3.28	0.63	0.37	7.00	Working under favorable conditions.
3.5	7 yr.	1 yr.	....	395,316	35.0	2.83	1.53	0.228	1.74	1.32	...	7.67	
3.5	6 yr. 6 mo.	1 yr.	7,344	461,882	35.0	2.85	1.48	0.195	1.71	1.07	...	7.32	Compact gravel land subject to overflow.
4	9 yr.	1 yr.	7,057	484,387	20.6	1.83	0.89	0.31	2.58	0.65	0.26	6.52	Remodeled dredge, uneven bed-rock, in places shallow.
5	6 yr.	1 yr.	....	481,184	25.0	3.28	1.46	0.39	2.97	1.52	...	9.55	Difficult ground, in places cemented gravel.
5	2 yr. 5 mo.	1 yr.	....	635,146	27.0	3.14	1.45	...	2.40	1.28	0.41	8.70	Difficult ground.
5	2 yr.	1 yr.	....	582,891	30.0	3.28	2.02	0.32	2.59	1.37	1.00	9.60	Difficult digging.
5	5 yr. 6 mo.	1 yr.	7,344	615,009	25.0	3.06	1.42	0.29	3.06	1.14	...	8.98	Difficult digging.
5	4 yr. 6 mo.	1 yr.	....	812,355	36.0	2.30[2]	1.08	...	2.95	...	0.35	6.65	Medium gravel with considerable clay, much brush on top soil.
5	3 yr. 5 mo.	1 yr.	5,798	1,148,480	25.5	0.88	0.52	0.05	1.77	0.25	0.35	3.80	Loose gravel, heavy overburden of sandy loam.
5	2 yr. 5 mo.	1 yr.	6,790	1,148,802	29.9	0.82	0.49	0.03	1.89	0.25	0.16	3.64	Loose gravel, heavy overburden of sandy loam.
5	4 yr. 7 mo.	1 yr.	6,644	599,614	38.5	1.77	0.92	0.25	4.03[3]	0.47	0.23	7.67	Difficult digging, working against 20-ft. bank.
7	9 mo. 10 days	1 yr.	5,088	838,885	35.0	1.19	0.69	...	1.22	0.26	0.17	3.53	Difficult digging, gravel coarse, partly cemented.[8]
7	1 yr.	1 yr.	6,313	1,114,605	27.6	1.21	0.62	0.03	1.81	0.29	0.11	4.07	Compact gravel.
7	3 yr. 9 mo.	1 yr.	6,390	1,033,694	26.5	1.08	0.64	0.14	2.69[4]	0.34	0.20	5.09	Compact gravel, heavy digging.
7	2 yr. 9 mo.	1 yr.	6,917	1,017,167	28.1	1.10	0.65	0.15	2.19[5]	0.28	0.14	4.51	Compact gravel, heavy digging.
7	3 yr.	1 yr.	6,352	935,322	33.4	1.26	0.85	0.06	3.06	0.31	0.34	5.88	Compact gravel
7	3 yr.	1 yr.	6,700	1,194,146	27.5	1.05	0.58	...	2.78	0.32	0.37	5.10	Compact gravel.
7.5	2 yr. 11 mo.	2 yr. 11 mo.	13,464	3,458,229	27.9	0.27	0.41	...	1.50	0.24	0.24	4.42[6]	Medium compact bench gravel.
7.5	9 mo. 6 days	9 mo. 6 days	5,582	944,879	28.9	0.95	0.58	...	1.30	0.27	0.39	3.55	Medium compact gravel with heavy overburden.
7.5	2 yr. 6 mo.	1 yr.	6,402	1,369,844	70.2	0.99	0.77	...	1.95	0.45	...	4.16	Medium gravel overlain with hydraulic tailings.
7.5	2 yr. 6 mo.	1 yr.	6,900	1,281,351	67.8	1.09	0.98	...	2.01	0.45	...	4.53	Medium gravel overlain with hydraulic tailings.
8	6 mo.	6 mo.	3,162	583,927	42.5	1.69	0.59	...	1.14	0.28	0.22	3.92	Light gravel, dredge working against 10-ft. bank.
8	4 mo. 8 days	4 mo. 8 days	2,369	626,624	24.0	[9]	[9]	[9]	[9]	[9]	...	2.47	
9	5 mo.	5 mo.	....	580,310	51.0	[9]	[9]	[9]	[9]	[9]	...	4.98	Cemented gravel, difficult digging, 20-ft. bank above water level.
13.5	8 mo.	8 mo.	4,478	1,803,201	19.0	1.02	0.47	...	0.60	0.12	0.09	2.30	Fine gravel, easy digging.

[1] Total possible time in year's work, 8,784 hours.
[2] Including general expense, management, etc.
[3] Heavy repair-cost due to new tumbler, conveyor-belt, repairs to digging-ladder, screens, etc.
[4] Replacing tumbler-shafts, conveyor-belt, and new screen included in repairs.
[5] New steel spud and screen in repairs.
[6] Depreciation charges included in total expense.
[7] A 7-ft. dredge is now working this ground at a profit.
[8] This dredge successfully replaced an open-connected bucket-dredge which could not handle ground at a profit.
[9] Segregated costs not given.

HYDRAULIC DREDGE.

The ordinary hydraulic dredge has a centrifugal pump to raise the earth and water, and a rotary cutter or a water jet to loosen the material. The discharge is carried through pipes supported on scows. Tough clay with very large boulders cannot be handled, and while sharp sand is excavated readily it cuts the pump and discharge pipe badly; but for soft material the hydraulic dredge is very satisfactory.

In the Transactions of A. S. C. E., 1884, Mr. L. J. Le Conte gives the cost of dredging in Oakland Harbor, Cal. The average output was 30,000 cubic yards per month for eight months. The best output was 60,000 cubic yards in 23 days of 10 hours each, with delivery pipe 1,100 ft. long. An output of 45,000 cubic yards in 19 days of 10 hours each was accomplished when the lift was 20 ft. above the water, with a pipe 1,600 to 2,000 ft. long. The dredge was equipped with a 6 ft. centrifugal pump, two 16 x 20 in. engines for the pump, two 12 x 12 in. engines for operating the cutter, etc., and two 100 h. p. boilers. On an average, 15 per cent of the material pumped was solid, but up to 40 per cent all solids could be carried. The daily cost was as follows:

Coal, oil and waste	$ 35.75
Crew of 9 men	25.00
Cook and board	7.00
Interest, depreciation and insurance	25.55
Repairs	10.00
Total	$103.30
10 men on pipe line	20.00
1,200 cu. yd. at 10 cents	$123.30

Mr. J. A. Ockerson, in the Transactions of A. S. C. E., 1898, gives the following cost of operating three dredges:

Name of dredge	Alpha	Beta	Gamma
Cost	$87,000	$217,000	$86,000
Capacity, sand per hour	600 cu. yds.	2,000 cu. yds.	800 cu. yds.
Draft	4 ft. 10 ins.	6 ft. 10 ins.	4 ft. 3 ins.
Main engines	300 H. P.	2,000 H. P.	500 H. P.
No. centrifugal pumps	1	2	1
Diam. centrifugal pumps runner	6 ft.	7 ft.	5 ft. 9 ins.
Diam. discharge pipe	30 ins.	33 ins.	34 ins.
Delivery head	20 ft.	29 ft.	37 ft.
Velocity of discharge, per sec.	10 ft.	14 ft.	10 ft.
Agitators or cutters	6—2½-in. jets	6 cutters	9—2½-in. jets
Coal used, 24 hours	500 bu.	2,088 bu.	400 bu.
Cost of running per day	$97.00	$221.63	$100.51

* Add $37 for steam tender and $12 for pile sinker per 12 hour.

Mr. Emile Low describes a small dredge used by the United States Government at Warroad River, Minn. The dredge is of the "seagoing hopper type" with stern wheel, but is also

adapted and equipped for use with a supported discharge pipe for river channel and river harbor dredging. The dimensions are: Length of hull, 100 ft.; width midship at main deck, 27 ft.; depth of hull midship, 8 ft. 6 in.; length over all, including stern wheel and revolving cutter on the bow, 158 ft.; height of hull and superstructure, 25 ft. 4 in.; draft light, 4 ft. 2 in.; draft loaded, 6 ft. 4 in. The machinery consists of the following:

Two 12 in. centrifugal pumps.

One 16 h. p. vertical engine operating the revolving cutter.

One 20 h. p. horizontal engine operating the cutter hoist, chain drums and rope spools.

Two 10 x 60 in. stern wheel engines.

One 6 x 10 in. duplex force pump.

Four hand power worm gears for manipulating the sand pit shutters.

Two 75 h. p. Scotch marine boilers.

The pumps are arranged to take material through trailing suction ends from both sides of the dredge and one pump is also connected with the suction end of the cutter for dredging in clay and other hard material. The dredge, complete with wood barge, pipe floats and small boats, cost $29,130. It commenced operation on May 7, 1904, and between that day and June 30 accomplished the excavation of 1,380 lin. ft. of channel with an average width of 100 ft. and a mean depth of 8 ft. The total excavation was 8,625 cu. yds. at an average cost of 21⅔ cents per cu. yd. for all expenses, including labor, fuel, supplies, subsistence, etc. The cost of subsistence per ration was 44 cents. The material dredged was equal quantities of hardpan and mud, the latter full of tough, fibrous roots. Stormy weather delayed the work 5½ days. The total excavation for the fiscal year July 1, 1904, to June 30, 1905, was 55,205 cu. yds. The average cost of excavation, including charges on account of the plant used, was 13.03 cents per cu. yd., and the cost of subsistence per ration 39 cents.

The following tables give some data concerning the best six hydraulic dredges in use on the Mississippi River.

The dredges Delta, Epsilon and Zeta are non-propelling, requiring the service of a tender and pile sinker, and Iota, Kappa and Flad are self-propelling.

TABLE 96—ORIGINAL COST OF PLANT

Name	Dredge	Tender	Pile Sinker	Total
Delta	$124,940	$47,862	$2,884	$175,686
Epsilon	102,000	47,862	2,884	152,746
Zeta	109,000	47,862	2,884	159,746
*Iota	100,480	......	.....	100,480
*Kappa	134,600	......	.....	134,600
*Flad	134,600	......	.....	134,600

* Self-propelling. Average cost for non-propelling, $162,726; average cost for self-propelling, $123,227; average cost of one plant, $142,976+.

TABLE 96—REPAIRS, RENEWALS, ALTERATIONS AND BETTERMENTS TO PLANT.

Name Date of Delivery	Repairs and Renewals	Alterations and Betterments	Totals
Delta, Aug., 1897........	$28,761.58	$20,634.20	$49,395.78
Epsilon, Mar., 1898.....	21,381.17	1,094.35	22,475.52
Zeta, Mar., 1898........	20,318.06	1,128.17	21,446.23
Iota, Aug., 1900........	13,155.28	8,174.19	21,329.47
Kappa, July, 1901.......	7,533.16	4,664.95	12,198.11
Flad, July, 1901........	6,605.63	4,737.61	11,343.24
Tenders, Oct., 1899......	....	....	*10,718.93
Pile sinkers, Dec., 1898..	....	....	* 883.15

* Average of 4. Repairs and renewals, average of 6, $16,292.48; repairs and renewals (omit Delta), average of 5, $13,798.66; alterations and betterments, average of 6, $6,738.91; alterations and betterments (omit Delta), average of 5, $3,959.85.

The average repairs, etc., per dredge for the last 3 years were $1,868.61.

96B—COST OF FIELD OPERATIONS.

Name	Number of Seasons Operated	Total Cost Field Operations	Total Hours in Commission	Total Working Hours
Delta	7	$135,651.40	16,648	7,605
Epsilon	7	120,444.42	14,891	5,159
Zeta	7	100,114.57	13,243	4,037
Iota	5	80,942.51	12,137	3,127
Kappa	4	58,780.57	9,411	2,882
Flad	4	62,218.32	9,561	3,200

Name	Average Cost per Month in Commission	Cost of Material Used in Field Repairs	Average Cost per Month Excluding Field Repairs
Delta	$5,866.71	$4,595.91	$5,667.95
Epsilon	5,823.65	4,310.65	5,615.23
Zeta	5,443.06	3,872.81	5,232.51
Iota	4,801.73	3,290.19	4,606.55
Kappa	4,497.08	1,881.42	4,353.14
Flad	4,685.41	997.79	4,610.27

Including field repairs, average monthly cost for operating a non-propelling dredge with tender and pile sinker, $5,711.14; same for a self-propelling dredge, $4,661.41; excluding cost of material for field repairs, the monthly cost of operating a non-propelling plant, $5,505.23; same for a self-propelling plant, $4,523.32.

The rated capacity of these dredges, based on an assumed velocity of 13 ft. per second in the discharge pipe and a carrying capacity of 10 per cent of sand, is 1,200 cubic yards per hour for the Delta and 1,000 cubic yards for each of the other dredges delivering through 1,000 ft. of pipe. In tests made in 1907, the following results were obtained:

96C—CAPACITY TEST OF THREE DREDGES

Name	Average Velocity per Second	Per cent of Sand	Average Sand per Hour
Delta	15.10 ft.	14.69	1,850 cu. yd.
Epsilon	16.78 ft.	20.68	2,553 cu. yd.
Zeta	16.48 ft.	11.14	1,364 cu. yd.

Field tests under actual conditions were made in 1898.

Dredge	Duration of Test, Hours	Average Cu. Yds. Per Hour	Remarks
Delta	27.38	1,295	Sand, max. rate 2,550 cu. yd. p. hr.
Epsilon	24.93	1,305	Sand.
Zeta	62.92	652	Blue clay and sand.

Tests made with only water pumped in 1902 would give the deductions:

96D—CAPACITY TESTS

Dredge	Average Velocity	Cubic Yds. per Hour 15% Sand	Cubic Yds. per Hour 10% Sand	Length of Pipe
Delta	16.65	2,160	1,440	500 ft.
Epsilon	21.20	2,404	1,600	500 ft.
Iota	18.36	2,114	1,400	500 ft.
Kappa	21.35	2,342	1,560	240 ft.
Flad	16.75	1,944	1,296	480 ft.
*Iota	21.30	2,342	1,560	500 ft.

* With shrouded runner.

The actual averages of all the dredges in all materials from clay to sand were: 1901, 567.0 yards; 1902, 481.6 yards; 1903, 422.9 yards; 1904, 537.1 yards; average, 500.0 yards. This average of 500 yards per hour can be depended on, under normal conditions, for 20 hours per day and 25 days per month. Allowing 10 per cent for idle time, this gives 252,000 yards per month. The season of 1904 lasted four months, on which basis 908,000 cubic yards per season could be accomplished.

The contract price of the Harrod, under construction in 1907, complete with pipe line and all auxiliaries, was $238,998.17. Its rated capacity based on an estimated velocity of 22 ft. per second in the discharge pipe and a carrying capacity of 10 per cent of sand is 2,100 cubic yards per hour. The cost of operating the Harrod is assumed to be $5,500 per month while in commission.

The following notes on the hydraulic suction dredge are from U. S. Dept. of Agr., Bul. 230:

For the construction of the larger levees the use of the hydraulic suction dredge is entirely feasible in connection with the use of other excavating machines. By the construction of the muck ditch a retaining bank will be built to as great height as the earth can be made to stand. A similar retaining bank

will be constructed at the other toe of the levee by depositing earth excavated from the nearest margin of the ditch. The space between the two retaining walls can then be filled by a hydraulic suction dredge, the discharge pipe being supported by a cantilever. This machine (Fig. 82), in its present state of development probably represents the most economical method now in use for excavating very large channels, unless the ladder dredge be excepted.

The following table indicates the cost of operating a hydraulic suction dredge on the New York Barge Canal in 1908. The dredge in question is of modern construction, has a 20-inch discharge pipe, and cost $115,000. A large part of the excava-

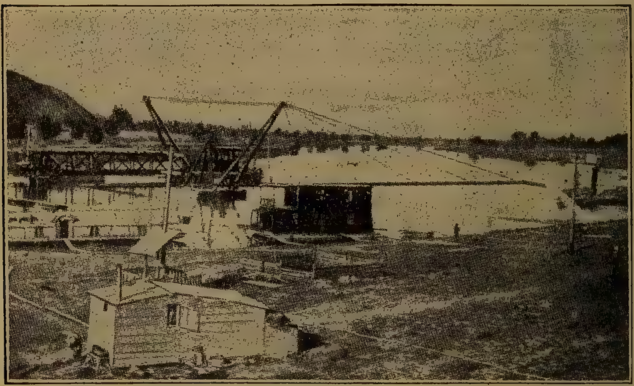

Fig. 82. Hydraulic Suction Dredge, Showing Discharge Pipe Supported by Cantilever.

tion was in stiff clay, though a part was in sand. The clay was of such firm texture that after remaining on the ground over winter the pieces had the same shape as when they were discharged from the end of the pipe line, still showing the marks of the cutter. While removing the old rock wall of the canal, the dredge was stopped sometimes twenty times a day, it is said, for removing boulders from the pump. Once during the season the dredge was sunk to the bottom of the canal. Otherwise the work was favorable, and the excavation made was representative of the capacity of the machine in ordinary clay soil. The charge against plant is intended to cover interest and depreciation at 15 per cent per annum. Under "Material" are included coal waste, tug hire, and similar items.

COST OF OPERATION OF HYDRAULIC SUCTION DREDGE ON THE NEW YORK BARGE CANAL FOR THE SEASON OF 1908.

Item.	April.	May.	June.	July.
Labor	$3,670.95	$5,169.29	$5,615.75	$ 5,835.14
Plant	408.30	1,367.60	1,677.85	1,735.50
Material	1,900.62	2,558.88	2,263.16	2,446.45
Total for month	$5,979.87	$9,095.77	$9,556.76	$10,017.09
Yards excavated	120,673	204,838	203,474	207,520

Item.	Aug.	Sept.	Oct.
Labor	$5,985.87	$4,993.11	$4,834.14
Plant	1,631.85	1,692.85	1,791.15
Material	2,320.92	2,430.05	2,573.50
Total for month	$9,937.94	$9,116.01	$9,198.79
Yards excavated	174,395	231,473	214,438

Unit cost for the season, 4.63 cents per yard.

An examination was made of several suction dredges on the New York Barge Canal and of the material excavated by them. In only one instance was the material at all comparable with that to be excavated in building the floodway levees, and in that instance the material was being removed at a cost of about 2½ or 3 cents per cubic yard, including all cost of maintenance, depreciation, repair and interest. The work planned for this type of machine on the St. Francis project is the excavation of large ditches outside the floodways, using the earth for constructing levees, and in dredging the channels of Tyronza and Little rivers. In the former case the work is estimated at 10 cents per cubic yard plus the cost of clearing and grubbing the ditch section at $150 per acre. In the second instance the work is estimated at 9 cents per yard, including the cost of clearing banks to enable the material to be deposited. This dredge can be used to advantage also for constructing two or three of the largest lateral ditches, which empty into ditches along the floodway.

In *Engineering-Contracting*, Vol. XXXV, No. 8, the following description is given of a hydraulic dredge, its tenders and capacities, etc.:

This dredge was used to fill in part of the Lincoln Park extension, Chicago, and was purchased in 1907. It is of the open end type, with a steel hull 148 ft. long by 38 feet wide and 10½ ft. deep. The main pump has 30 in. suction and discharge, and the main engines are of the triple expansion marine type of 1,200 i. h. p. The two double-ended marine boilers, 10 ft. 6 in. by 18 ft. long, with eight corrugated furnaces, were fitted at the beginning of last season with underfeed stokers. The installation of engine room auxiliaries includes condenser, independent air pump, independent circulating pump, fire and bilge pumps and an electric light outfit. The rotary cutter is adapted to hard clay material and its edges are of hard steel

and are movable. Two season's work have worn the cutting edges badly and manganese steel will probably be substituted. The dredge is anchored by heavy spuds operated by power. It can make a radial cut 175 ft. wide with a maximum depth of 35 ft. The dredge is provided with a complete repair shop and living quarters for the crew.

The pipe line adopted has a central conduit 30 in. in diameter, carried by two cylindrical air chambers 33 in. in diameter. The sections are 95 ft. long and are joined with the usual rubber sleeve. The material excavated was very stiff gumbo.

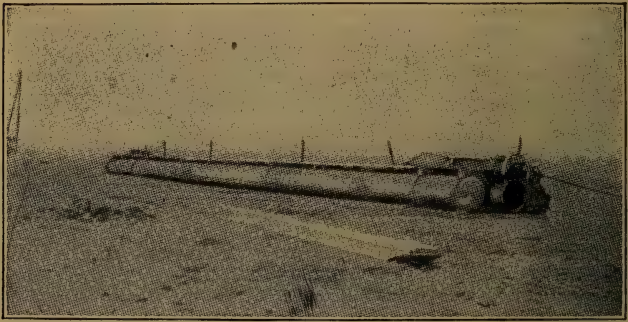

Fig. 83. View of Pontoon Discharge Pipe Used in Connection with the 30-in. Hydraulic Dredge.

TABLE 97.

I. TIME REPORT OF DREDGE "FRANCIS T. SIMMONS" FOR 1910

1910.	Available Working Time. Hrs.	Pumping Time. Pct.	Weather. Pct.	Misc. Pct.	Total. Pct.
April	624	47.0	36.5	16.5	53.0
May	600	57.7	19.0	23.3	42.3
June	624	80.0	1.0	19.0	20.0
July	600	68.4	14.0	17.6	31.6
August	648	52.0	29.0	19.0	48.0
September	600	63.5	9.5	27.0	36.5
October	624	54.0	18.0	28.0	46.0
	4,320	60.2	18.2	21.6	39.8

II. ANALYSIS OF WORKING TIME

September, 1910.	Hrs.	Mins.	Pct.
Total available time	600	..	....
Dredge worked	381	20	63½
Delays	218	40	36½

Causes of Delays:	Hrs.	Mins.	Pct.
Weather	57	5	9.5
Short pipe	31	40	5.28
Suction pipe, pumping and plug	11	20	1.89
Pontoon line	31	55	5.32
Swinging cables	15	10	2.52
Main engine	24	..	4.0
Spud engine	..	25	0.08
Cutter engine	..	..	....
Cutter shaft	..	..	....
Moving dredge to new cut	5	5	0.82
Towing and preparation	34	5	5.68
Miscellaneous	1	10	0.19
Stones	6	45	1.12
	218	40	36.40

Fig. 84. View of 30-in. Hydraulic Dredge "Francis T. Simmons" in Operation in Lake Michigan.

III. COST OF OPERATION AND REPAIRS OF DREDGE, 1910; TOTAL TIME IN COMMISSION, 4,320 HOURS

Operation.	Totals.	Per. hr.	Per cu. yd.
Labor	$13,855.45	$ 3.2073	$0.0243
Fuel	17,000.35	3.9353	.0300
Supplies, tools, sleeves, oil, etc	4,323.52	1.0008	.0076
Commissary labor and supplies	6,010.90	1.3914	.0104
Field repairs, labor and material	6,040.82	1.3983	.0106
Tug service	13,587.83	3.1453	.0238
Derrick service	327.20	.0757	.0005
Motor boat	584.00	.1352	.0010
Insurance	3,500.00	.8102	.0060
Winter repairs and fitting up:			
Labor	5,267.68	1.2194	.0093
Material	2,164.25	.501	.0037
Fuel commissary and tools	1,025.41	.2374	.0018
Tug service	753.08	.1743	.0013
Totals:			
Operation	65,230.07	15.0996	.1142
Repairs	9,210.42	2.1320	.0161
Operation and repairs	$74,440.49	$17.2316	$0.1303

IV. FOUR YEARS' OPERATION OF DREDGE

Cubic yards	457,242*	672,815*	518,920*	570,243†
Cost	$54,241.19*	$88,459.17*	$69,202.32*	$74,440.49†
Cost per cubic yard	$0.118	$0.131	$0.133	$0.130
Hours in commission	2,940	27.6	3,291	4,320
Hours pumping	1,088=37 %	4,500=60.6%	2,117=64.3%	2,599
Hours delayed account weather	683=23.2%	636=14.4%	294= 9.0%	788=18 %
Hours delayed, miscellaneous	1,169=39.8%	1,100=25 %	880=26.7%	933=21.6%
Hours delayed, total	1,852=63 %	1,736=39.4%	1,174=35.7%	1,720=39.8%
Output per pumping hour, cubic yards	426	245.8	245	220
Cost of coal	$10,131.04	$16,050.68	$11,584.37	$17,000.35
Cost of coal per cu. yd.	$0.022	$0.024	$0.022	$0.03

*Based on calculation of cut measurement.
†Based on calculation of place measurement.

The operating crew of the dredge is as follows:

	Per mo.
1 Chief operator	$150.00
1 Assistant operator	125.00
1 Chief engineer	150.00
1 Assistant chief engineer	110.00
4 Oilers	66.00
4 Firemen	66.00
4 Coal passers	55.00
2 Spudmen	66.00
1 Janitor	55.00
8 Deckhands	55.00
Commissary:	
1 Steward	86.00
1 Second cook	40.00
1 Porter	40.00

The following data are for the year 1911:

V. TIME REPORT OF DREDGE, 1911

Available working time, hours	4,620
Pumping time, hours	3,288½
Pumping time, percentage of total time	71.2

Delays:	Hours.
Weather, 6.2%, or	288
Miscellaneous, 22.6%, or	1,043⅓
Total delays, 28.8%, or	1,331½

The best month's work was in November, when the working time efficiency was 79.5 per cent. The dredge was started for the year on April 15, during which month the working time was 65 per cent of the total. The dredge went out of commission November 30. The working season, then, was 7½ months, or 62.5 per cent of the year. In calculating interest charges on this equipment, the monthly interest must be taken at $1/12 \times \frac{100}{62.5} \times$ annual interest.

VI. COST OF DREDGE OPERATION AND REPAIRS

Total yardage 735.425

Operation.

	Sub-totals.	Cost per cu. yd.
Labor	$18,573.85	
Administration	1,112.56	
Watching	178.66	
Total	$19,865.07	$0.027
Fuel	$17,726.58	0.024
Supplies, tools, sleeves, oil, etc.	6,786.66	0.009
Commissary, labor	1,500.00	
Supplies	6,067.37	
Total	$ 7,567.37	0.010

VI—Continued

Repairs, labor	$ 535.75	
Material	1,390.10	
Derrick	951.59	
Total	$ 2,877.44	$0.004
Towing, "Richard B."	$ 2,377.16	
"Keystone"	5,512.06	
"Hausler"	11,455.41	
Total	$19,344.63	$0.026
Miscellaneous:		
Teams	$ 65.33	
Insurance	4,101.53	
Motor boat	363.37	
Scow service	270.42	
Pile driver	245.38	$0.007
Total	$ 5,046.03	$0.007
Total operation	$79,213.78	$0.107
REPAIRS.		
Labor	$ 7,057.58	$0.010
Material	5,746.50	0.008
Fuel	468.75	0.0006
Supplies	171.25	0.0002
Commissary	826.24	0.0011
Dunham tug	76.00	
"Richard B."	485.59	
"Keystone"	174.07	
"Hausler"	201.63	
Total	$ 937.29	$0.0012
Miscellaneous teams and pile driver	147.55	
Derrick	$ 357.46	
Total	$ 505.01	$0.0007
Grand total, repairs	$15,712.62	$0.022
Total operation and repairs	94,926.40	0.129

During the season no repairs involving any extended loss of time were necessary. There was no loss of time due to the main pump and only 2¼ hours on account of repairs to the main engines. A short connecting section of cast iron in the discharge was worn through and replaced with cast steel. The cast steel pump casing and elbows show very little wear.

The pontoon pipe was lined with an auxiliary wearing lining covering the bottom third of the pipe. This ⅜-inch sheet was worn and was replaced for the 1912 season's work. The rubber sleeves joining the sections of the discharge pipe gave fairly good service. The average life of a sleeve was 41 days; but eliminating those sleeves which were damaged due to the condition of the pontoons, the average life of a sleeve was 54 days. The cutter blades required to be renewed each year.

Cost of Dredge. The following table gives the list of items

which together make up the cost of the dredge as it was put in operation in 1910:

Engineering, plans, inspection, etc.	$ 9,816.45
Contract (1907) with 2,000 ft. pontoons	151,402.19
Terminal pontoon scow (1907)	1,227.88
8 Jones underfeed stokers (1908)	6,700.00
6 Pontoons (1908)	10,485.00
Miscellaneous	874.04
Total	$180,505.56

COST OF TENDERS.

(For the cost of the tugs operating in connection with this dredge see Tugs, p. 644.)

A motor boat costing $1,150 was used for transportation of the men, etc. One hundred and forty-six days of its time, at a cost of $4.00 per day, were charged to the dredge.

A hydraulic dredge was employed in the harbor improvements at Wilmington, Cal. The following statement shows the cost of dredging from April 1 to June 30, 1905:

Routine office work, labor	$ 673.33
Care of plant and property, labor	180.00
Surveys, labor and supplies	155.63
Towing and dispatch work, labor, fuel and supplies	316.00
Alterations and repairs to dredging plant, labor and material	2,432.52
Operating dredge, including superintendence and labor charges, fuel, fresh water, lubricants, and all other supplies	10,084.54
Deterioration of plant and property, estimated	2,263.94
	$16,105.96

Cost per cubic yard, $0.0708.

In addition to the hydraulic dredge, the following auxiliary floating plant is employed: A gasoline launch, length over all 30 ft. 1½ in., 7 ft. beam, depth 3 ft. 7 in., propelled by a 16 h. p. "Standard" engine. Also nine pontoons, each 35 ft. x 10 ft. x 3 ft.; 15 pontoons, each 21 ft. 3 in. x 10 ft. x 3 ft.; one water boat, 34 ft. 9 ins. x 10 ft. x 4 ft. 6 ins.; one oil boat, 34 ft. 9 ins. x 10 ft. x 4 ft. 6 ins.; one derrick boat, 29 ft. 6 ins. x 10 ft. 7 ins. x 3 ft. 10 ins. The original cost of the dredging plant was as follows:

20 inch suction dredge	$ 99,453
Gasoline launch	1,733
Discharge pipe line for dredge	3,023
Rubber sleeves	1,275
Pontoons and barges	6,501
Skiffs	154
	$112,139

On the Chicago canal two dredges were used, which are described in Engineering News, September 6, 1894. Each dredge was equipped with a 6-inch centrifugal pump and a 250 h. p. engine. The discharge pipe was 18 in. in diameter, made in 33 ft. lengths, coupled with rubber hose held by iron clamps. Each dredge averaged 1,732 yards in 10 hours.

In *Engineering News*, October 30, 1902, Mr. John Bogart, in charge of the Massena (N. Y.) canal, gives the cost of operating two dredges. Dredge No. 1 cost $40,000. It had a 12-inch wrought iron discharge pipe, a rotary cutter, and a centrifugal pump driven by a Lidgerwood compound condensing engine of 125 h. p. It lifted the material 30 feet above the water and discharged it through a 2,000-foot pipe. The depth of cut was 22 feet below the water surface. The output averaged 1,125 yards in 22 hours, at a cost of $95.80, or 8½ cents per yard.

Fig. 85. 20-inch Hydraulic Dredge Designed and Equipped to Work on New York State Barge Canal. This Dredge Has Delivered 456,000 Cubic Yards in One Month and Cost $76,000, Not Including Pipe Line or Pontoons.

Dredge No. 2 cost $60,000. Its discharge pipe was 18 inches in diameter. The output averaged 1,554 cubic yards at a cost of $145, or 9.4 cents per yard.

Otto Fruhling, a German contractor, dredge operator and designer, has developed a new system of suction dredging. In this system an inverted dipper dredge bucket, at the end of the suction pipe, scrapes up and collects the dredged material before the suction forces come into play. This dredge is described by Mr. John Reid in an article in *Engineering News*, from which the tables on following pages are taken.

TABLE 98—COMPARISON OF FRUHLING HYDRAULIC DREDGE VII. WITH AMERICAN HYDRAULIC HOPPER DREDGES.

	Fruhling No. VII.	Atlantic and Manhattan.	Delaware.	Ancon and Culebra.	Mills and Thomas.
Length	265′0″	274′0″	300′0″	274′0″	300′0″
Breadth	48′0″	47′6″	52′0″	47′6″	52′6″
Depth	20′0″	25′0″	22′6″	25′0″	25′0″
Draft loaded	16′0″	18′0″	18′3″	18′0″	23′0″
Hopper capacity (cu. yds.)	2,000	2,300	2,200	2,300	3,000
Number and diameter of suction pumps	2@5′2″	2@9′0″	2@8′2″	2@9′0″	1@8′0″
Revolutions per minute	180 to 200	180	180	180	126
Cu. yds. pumped per minute	**33**	**10**	**11**	10	12.2
Cu. yds. pumped per hour	1,980	600	660	600	732
Hopper contents in average load (cu. yds.)	1,900	2,149	2,200	....	2,200
Time to dredge average load (minutes)	57	*220	200	....	*180
Indicated horsepower (on propellers)	2,000	1,800	1,800	1,800	2,000
Speed loaded (knots)	10	10	10	10	8
Cost in United States (each vessel)	$375,000	$350,000	$375,000	$365,000	$490,000

* Average time taken to fill hopper during one year's work.

Note.—Material in all cases was fine sand mixed with mud, as found in New York and Delaware channels. Results from "Ancon" and "Culebra" would be similar to those for "Atlantic" and "Manhattan."

COMPARISON OF FRUHLING AND COMMON SUCTION DREDGES.

	Atlantic.	Fruhling.
Length	288 ft. 0 ins.	187 ft. 0 ins.
Breadth	48 ft. 0 ins.	34 ft. 6 ins.
Depth	23 ft. 0 ins.	14 ft. 9 ins.
Draft (loaded)	18 ft. 3 ins.	13 ft. 1 in.
Hopper capacity	2,300 cu yds.	785 cu. yds.
Hopper contents per load	2,040 cu. yds.	700 cu. yds.
Hopper filled (in minutes)	220	44

	Atlantic.	Fruhling.
Cu. yds. lifted per hour	558	940
Cu. yds. lifted per minute	9.3	15.7
Speed loaded (knots)	10	9.75
Dredging depth	35	35
Cost in the U. S.	$350,000	$200,000

DRILLS

TABLE 99—CATALOGUE DATA ON ROCK DRILLS.
(As given in the various catalogues of the makers.)

RECIPROCATING TYPE.

Ref. No.	Manufacturer.	Unit.
2.	Kind of drill	
3.	Model	
4.	Diameter of cylinder	Inch
5.	Length of stroke	Inch
6.	Displacement of piston hammer	Cu. in.
7.	Approximate strokes per minute under 75 lbs. pressure at drill	No.
8.	Approximate displacement of piston hammer per minute at 75 lbs. pressure	Cu. ft.
9.	Length of drill from end of crank to end of piston	Inch
10.	Diameter of octagon steel used	Inch
11.	Size of shank	Inch
12.	Depth of hole drilled without change of bit (length of feed)	Inch
13.	Depth of vertical hole each machine will drill easily from 1 to	Ft.
14.	Number of pieces in set of steels to drill holes to depth as stated	
15.	Diameter of holes drilled as desired (at bottom)	Inch
16.	Diameter of supply inlet (standard pipe)	Inch
17.	Size of boiler for ample steam supply, 1 drill	H. P.
18.	Diameter of steam pipe to carry steam 100′ to 200′	Inch
19.	Weight of drill unmounted with wrenches and fittings, unboxed	Lbs.
20.	Weight of drill unmounted with wrenches and fittings, boxed	Lbs.
21.	Weight of tripod, without weights, unboxed	Lbs.
22.	Weight of holding down weights	Lbs.
23.	Weight of drill, tripod, weights, fittings and wrenches (boxed)	Lbs.
24.	Weight of double screw columns, complete	
25.	Weight of one 50′ length of hose (boxed)	Lbs.
26.	Price of drill unmounted, with wrenches and fittings, without tripods or column*	$
27.	Price of drill complete, including drill, tripod, weights, throttle, oiler and wrenches*	$
28.	Price of double screw column, complete*	$

* Subject to a discount of from 15% to 40%, depending upon the makers, size of order, and price of steel.

HAMMER DRILLS.

2.	Kind of drill	
3.	Model	
4.	Diam. of cylinder	Inch
5.	Length of stroke	Inch
6.	Displacement of piston hammer	Cu. in.
7.	Length over all	Inch
7-A.	Length of air feed stoping drills extended	Inch
8.	Diameter of hexagon steel used	Inch
9.	Size of shank	Inch
10.	Depth of hole each machine will drill easily	Ft.
11.	Diameter of holes drilled as desired (at bottom)	Inch
12.	Diameter of supply inlet (standard pipe)	Inch
13.	Size of hose used	Inch
14.	Weight of drill (unboxed)	Lbs.
15.	Weight of drill (boxed)	Lbs.
16.	Weight of 50′ length of hose (boxed)	Lbs.
17.	Price of drill†	$

†Subject to a discount of from 10% to 30%, depending upon the makers, size of order and price of steel.

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Ingersoll-Rand "Sergeant"									Ingersoll-Rand Submarine Type		
2												
3	A-86	B-24	C-24	D-24	D-44	E-24	E-44	F-24	F-94	G-107	H-64	K-64
4	2¼	2½	2¾	3	3	3¼	3¼	3½	3⅝	4¼	5½	6½
5	5	6	6½	6½	6½	6½	6½	7	7½	8	8	9
6	19.9	29.5	38.7	46	46	53.9	53.9	67.3	77.5	113.5	190	298.5
7	500	500	375	350	350	350	350	300	300	400	250	250
8	5.76	8.54	8.39	9.32	9.32	10.9	10.9	11.68	13.45	26.3	27.5	43.3
9	37	41	48	48½	48½	49	49	52	52½	51¼	81	90
10	⅞–¾	⅞–1	1–1⅛	1⅛–1¼	1⅛–1¼	1⅛–1¼	1⅛–1¼	1¼–1⅜	1¼–1¾	1½–1¾	2–2½	2–2½
11	⅞x5	⅞x5	1x5½	1⅛x6	1⅛x6	1⅛x6	1⅛x6	1¼x6	1¼x6	1¾x6½	2x8	2x8
12	15	20	24	24	24	24	24	24	24	...	...	...
13	6	8	10	14	14	16	16	20	20	27	40	60
14	5	5	5	7	7	8	8	10	10	...	...	...
15	¾–1½	1–1½	1¼–2¼	1¼–2¼	1½–2¼	1¾–2¾	1¾–2¾	1¾–3	1¾–3	3–6	3–6	3–6
16	¾	1	1	1	1	1	1	1	1	1¼	1¼	1¼
17	6	8	8	8	8	10	10	10	10	15	18	25
18	¾	1	1	1	1	1	1	1¼	1¼	...	...	...
19	140	190	270	280	285	295	300	405	410	420	1100	1250
20	170	235	320	330	335	345	350	465	470	570	1350	1500
21	85	165	165	165	165	210	210	275	275	...	...	...
22	120	270	285	285	285	330	330	375	375	...	...	...
23	430	750	855	865	870	970	975	1225	1230	...	...	...
24	140	227	258	344	344	344	344	410	450	...	...	...
25	100	100	100	100	100	100	100	100	100	...	...	...
26	170	200	220	240	240	260	260	280	290	325	550	650
27	...	...	...	...	...	...	...	...	...	...	...	...
28	45	55	60	70	70	70	70	73	73	...	...	...

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Ingersoll-Rand Improved "Sergeant" Type					Ingersoll-Rand "Butterfly" Type	Leyner-Ingersoll Water Drill	Hardsocg Wonder Drill Co. Hardsocg Wonder (Reciprocating)			
2											
3	B-104	F-104	F-105	G-104	G-105	C-110	Drill	S	U	V	W
4	2½	3½	3½	4¼	4¼	2¾	2½	2¼	2¾	3⅛	3¼
5	5	7	7	8	8	6¼	3	5¼	6¼	6¾	6¾
6	24.5	67.3	67.3	113.4	113.4	37	14.7	20.9	37.1	51.8	56
7	650	500	500	400	400	600	...	...	...	...	...
8	9.2	19.5	19.5	26.2	26.2	12.8	...	...	...	...	...
9	37	47¼	68½	57¾	73½	42	47¾	...	...	...	...
10	1	1¼	1¼	1½	1½	⅞–1⅛	1¼ *	⅞	1	1⅛	1¼
11	...	...	...	1½x6½	1½x6½	...	...	...	...	...	...
12	20	24	48	30	48	24	24	20	26	26	26
13	6	18	20	27	27	8	8–12	8	14	18	20
14	4	9	5	11	7	4	4	6	7	9	10
15	¾–1½	1⅜–3	1⅜–3	2½–5	2½–5	1–1½	1–2½	1⅛	1½	1⅜	1⅜
16	¾	1	1	1¼	1¼	¾	¾ †	...	...	...	...
17	8	10	10	15	15	...	...	6	8	10	10
18	1	1¼	1¼	1¼	1½	...	...	...	...	...	...
19	130	337	400	550	950	137	150	145	215	275	285
20	160	390	480	660	950	180	195	...	...	...	...
21	160	296	296	315	315	174	90	300	565	565	565
22	255	370	370	370	370	336	210				
23	...	...	...	...	...	...	...	...	...	...	...
24	140	410	410	...	...	227	227	120	375	385	385
25	100	100	100	100	115	100	100	105	105	105	105
26	200	280	280	325	325	220	300	200	220	275	300
27	...	...	...	...	...	...	...	250	275	340	365
28	45	73	73	...	...	55	55	60	70	70	70

* Round hollow steel. † ¾″ air, ½″ water

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	McKiernan-Terry Drill Co. Spool Valve Type "S"							McKiernan-Terry Corliss Valve Type "TC"				Chicago Pneu. Tool Co. "Chi. Gatling"
2												
3	S2¼	S2½	S2¾	S3	S3¼	S3⅝	S4¼	TC2¾	TC3	TC3¼	TC3⅝	C22
4	2¼	2½	2¾	3	3¼	3⅝	4¼	2¾	3	3¼	3⅝	2¾
5	4¼	5	5½	6½	7	7½	8½	6½	6½	6½	8¾	6½
6	16.9	24.5	32.7	46	58	77.5	120.5	38.7	46	53.9	90.5	38.7
7	...	...	...	...	...	...	...	...	...	...	...	700*
8	...	...	...	...	...	...	...	...	...	...	...	15.7
9	...	...	...	...	...	...	...	...	...	...	...	42
10	¾–⅞	⅞–1	1–1⅛	1–1⅛	1¼–1⅜	1¼–1⅜	1⅜–1½	1–1⅛	1⅛–1¼	1¼–1⅜	1¼–1⅜	1
11	...	...	...	...	...	...	...	...	...	...	...	...
12	12	20	24	24	24	24–30	24–30	24	24	24	24–30	20–24
13	6	10	12	14	16	25	30	12	14	16	25	8
14	6	6	6	7	8	10	12	6	7	8	10	5
15	¾–1½	1¼–2	1¼–2	1½–2¼	1¾–3	1¾–3	2–3½	1½–2	1½–2¼	1¾–3	1¾–3	1¼–1¾
16	½	¾	1	1	1	1	1¼	1	1	1	1	¾
17	5	8	8	8	10	10	12	8	8	10	10	...
18	¾	1	1	1	1	1¼	1¼	1	1	1	1¼	...
19	95	170	210	255	290	407	440	230	279	310	430	145
20	135	205	270	310	350	475	515	285	344	375	500	200
21	81	162	162	223	223	334	334	162	223	223	334	200
22	171	219	219	309	309	432	432	219	309	309	432	300
23	...	...	...	...	...	...	...	...	...	...	...	...
24	200	200	352	352	352	518	518	352	352	352	518	120
25	...	...	...	...	...	...	...	...	...	...	...	...
26	210	240	250	275	300	320	365	250	275	300	320	220
27	255	300	310	347	372	404	449	310	347	372	404	275
28	55	55	65	65	65	80	80	65	65	65	80	32

* 80 lbs. pressure.

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Chicago Pneumatic Tool Co. "Chicago Slogger"				Sullivan Mach. Co. "Liteweight"			Sullivan Machinery Company "Hy-Speed"				
2												
3	C-2	D-2	E-2	F-2	FF-12	FL-12	FP-12	FG-3	FJ-3	FL-3	FP-3	FS-3
4	2¾	3	3¼	3⅝	2⅝	3¼	3⅝	2¾	3	3¼	3⅝	4¼
5	6½	6½	6½	7½	5¾	6½	7	5½	6	6½	7	7¾
6	38.7	46	53.9	77.5	31.1	53.9	72.3	32.7	42	53.9	72.3	110
7	375	350	350	300	...	...	...	...	...	...	...	...
8	8.4	9.3	10.9	13.5	...	...	...	...	...	...	...	...
9	48	48	48	52	...	...	...	...	...	...	...	...
10	1⅛–1¼	1⅛–1¼	1⅛–1¼	1¼–1⅜	1–1⅛	1¼–1⅜	1⅜–1½	1⅛–1¼	1⅛–1¼	1¼–1⅜	1⅜–1½	1½–1⅝
11	...	...	...	...	1x6½	1¼x7⅛	1⅜x7¼	1⅛x6¾	1⅛x6⅞	1¼x7⅛	1⅜x7¼	1½x7¾
12	24	24	24	24	22	24	24	24	26	28	30	36
13	10	14	16	20	11	18	20	14	17.3	18.7	20	27
14	5	7	8	10	6	9	10	7	8	8	8	9
15	2–2½	1¾–2½	1⅝–2½	1½–2⅝	1⅜–2	1¾–2¾	1⅞–3	...	...	...	...	...
16	1	1	1	1	¾	1	1	1	1	1	1	1¼
17	8	8	10	10	8	10	12	8	8	10	12	15
18	1	1	1	1¼	1	1¼	1½	1	1¼	1¼	1½	1½
19	285	295	330	400	162	295	325	250	275	330	380	640
20	365	380	407	483	227	340	400	290	320	375	455	855
21	233	233	233	376	215	240	370	215	215	240	370	370
22	312	312	312	405	305	310	400	305	305	310	400	400
23	1042	1084	1084	1375	...	...	...	...	...	...	...	...
24	182	182	182	265	250	380	430	320	380	380	430	430
25	100	100	100	100	...	...	...	...	...	...	...	...
26	220	240	260	290	...	...	...	...	...	...	...	...
27	285	305	325	365	...	...	...	...	...	...	...	...
28	40	40	40	43	...		...	...	...	...	...	...

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Sullivan Mach. Co. Differential Valve Type UA	US	UB	Wickes Brothers "Murphy Little Champion" A	B	C	D	E	F	G	H
2											
3	UA	US	UB	A	B	C	D	E	F	G	H
4	2	2¼	2½	2½	2½	2¾	3	3⅛	3¼	3½	3⅝
5	4½	5	5	5½	6	6½	6½	6¾	7	7½	8
6	14.1	19.9	24.5	27	29.4	38.6	46	51.7	58	72.1	82.7
7	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...
10	¾–⅞	⅞–1	⅞–1	¾–⅞	⅞–1	1–1⅛	1⅛–1¼	1⅛–1¼	1⅛–1¼	1¼–1⅜	1¼–1⅜
11	...	...	...	¾x4	⅞x4	1x5½	1⅛x5½	1⅛x5½	1⅛x5½	1¼x6	1¼x6
12	12	15 or 20	20	15	20	24	24	24	24	24	30
13	4	5	6	5	6	10	12	14	16	20	25
14	4	3 or 4	4	4	4	5	6	7	8	10	10
15	⅝–1¾	⅞–2	1–2¼	⅞–2	1–2¼	1¼–2½	1¼–3	1¼–3	1¼–3	1½–3½	1½–4
16	¾	¾	¾	¾	¾	1	1	1	1	1	1
17	5	6	8	...	...	...	...	...	...	...	...
18	¾	1	1	1	1	1¼	1¼	1¼	1½	1½	1½
19	110	145	165	125	165	235	245	270	290	340	395
20	145	180	200	...	...	...	...	...	...	...	...
21	115	115	215	85	170	170	200	200	200	315	315
22	210	210	305	125	290	290	340	340	340	400	400
23	...	...	...	455	755	830	910	935	960	1205	1260
24	165	165 or 250	250 or 320	...	...	...	...	...	...	...	...
25	...	...	...	95	95	105	105	105	105	105	105
26	...	...	...	200	225	250	275	285	300	325	350
27	...	...	...	230	275	300	325	335	350	385	410
28	...	...	...	...	...	...	...	...	...	...	...

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Ingersoll-Rand		Ingersoll-Rand				Hardsocg Wonder Drill Co.					
2	"Jackhamer"		"Butterfly"				"Little Wonder"					
3	BBR-13	BCR-430	BA-23	BA-26	BC-23	BC-26	1	20	30	44	50	53
4	2⅜	2¼	1½	1½	2	2	1⅝	1 13/16	1 31/32	1 13/16	1 31/32	1 13/16
5	1⅞	2	3½	3½	4	4	...	...	...	...	...	...
6	8.7	8.95	6.2	6.2	12.6	12.6	...	...	...	...	...	...
7	17¾	18	22½	22½	24	24	...	...	...	...	...	...
8	⅞	⅞	⅞–1	⅞–1	1–1⅛	1–1⅛	⅞	⅞	1	⅞	1	⅞
9	⅞x3¾	⅞x3¼	...	...	...	...	⅞x3	⅞x3	1x3½	...	...	⅞x3
10	6	6	5	5	8	8	4–5	4–6	6–10	4–6	6–8	4–6
11	1⅛–1¼	1⅛–1¼	1¼	1¼	1¼	1¼	...	...	...	...	...	...
12	½	½	½	½	½	½	...	...	...	...	...	...
13	¾	¾	¾	¾	¾	¾	½	½	¾	½	¾	½
14	29 & 34	40	43	51½	53	64	20	30	45	40	50	34
15	46	60	6	70	75	95	...	...	...	...	...	...
16	100	100	100	100	100	100	...	...	...	...	...	...
17	100*	100*	100	110	125	135	...	...	...	...	...	...

* Net price.

Ref. No.	Hardsocg Wonder		McKiernan-Terry				Chicago Pneu. Tool Co.		Cleveland Rock Drill Co.	
2	Auto. Rotating		"Busy Bee"			"Sinker"	"Chi. Sinker"	"Valve-less"	Hand Sinker	
3	60	70	C-3	B-1	B-4	A-3	B-46	K-1¾	25-H	50-H
4	1⅞	2⅛	1⅝	1¾	...	2	2⅛	1¾	...	...
5	...	...	3	4	...	3⅝	4	2	...	...
6	...	...	6.2	9.6	...	11.4	14.2	4.8	...	...
7	...	...	17	17	...	27	24	15	22	22
8	⅞	1	⅞–1	⅞–1	⅞–1	1	1	⅞	⅞	1
9	⅞x3	1x3½	...	...	...	...	...	⅞–3	...	...
10	4–6	6–10	4	8	8	12	6–10	6	6	15
11	...	...	1¼	1¼	1¼	...	1 5/16	1 1/16	...	...
12	...	...	½	½	½	¾	...	...	...	...
13	¾	¾	½	½	½	¾	¾	½	½	¾
14	40	47	28	50	85	92	43	29	30	60
15	...	...	38	65	92	130	...	...	...	...
16	...	...	...	...	...	...	...	...	...	...
17	...	...	50*	75*	100*	130*	90	50*	...	...

* Net price.

TABLE 99—CATALOGUE DATA—Continued

Ref. No.	Sullivan Machinery Co. Hand Feed Drills			
2				
3	DB-13	DB-15	DC-19	DB-21
4	$1\frac{1}{16}$	...	1¾	2
5	2⅛	...	...	3½
6	1.9	...	...	11
7	15⅝	...	21⅝	...
8	⅞	⅞	1	1
9	$\frac{11}{16}$x2½	⅞x3	1x3½	...
10	...	4	6	8
11	1¼	1¼–1½	1¼–2	1¼–2
12	½	...	...	...
13	$\frac{7}{16}$	$\frac{7}{16}$	½	¾
14	14	25	45	62
15	...	...	...	...
16	...	...	...	...
17	...	...	...	...

Ref. No.	Ingersoll-Rand Imperial Stope Drill	Ingersoll-Rand "Butterfly" Type			McKiernan-Terry Stoper	McKiernan-Terry Stoper & Drifter
2						
3	MC-30	BC-20	BC-21	BC-22	A-4	A-5
4	$1\frac{3}{16}$ & $2\frac{11}{16}$	2	2	2	...	...
5	3½	4	4	4	...	...
6	3.6 & 19.8	12.6	12.6	12.6	...	...
7	53½	55½	52½	56½	63	63
7A	73½	77½	74½	78½	92	92
8	⅞–1¼	1–1+	1–1+	1–1+	1	1
9	...	...	...	...	...	...
10	12	12	12	12	12	12
11	...	...	...	...	...	...
12	½	½	½	½	¾	¾
13	¾	¾	¾	¾	¾	¾
14	70	81	72	83	100	124
15	100	100	100	100	150	225
16	100	100	100	100	...	...
17	145	145	145	145	175*	195*

* Net price.

EXPERIENCE TABLE OF COST OF DRILLING*

For the cost column all figures are given on the following standard basis. Drilling alone, not including mucking superintendence, and overhead charges, etc.

Drill Runner: Dry work, 25 cents per hour. Subaqueous, 27½ cents per hour.
Helper: Dry work, $1.75 per day. Subaqueous, 22 cents per hour.

1	2	3	4	5	6	7	8	9
Actual Drilling Labor per Foot of Hole, Cents	Kind of Work	Kind of Rock	Kind of Drill	Depth, Hole	Starting Bit	No. of Men to Drill	Special Conditions	Authority
0.743	Anchor bolt holes	Green concrete	Steam	6′	1½″	....	Drill hung on a pile-driver allowing 1 long bit to be used. Water jet used.	G&H
1.62	Subaqueous	Sandstone	Steam	7′	4¾″	2	G. L. No. 5 at West Neebish Chan. See p. 159.	Dana
2.00	Plug holes in quarry	Granite	Pneumatic plug drill.	3″	....	1	250 holes in a good day's work.	Gillett
3.53	Subaqueous	Limestone	Steam	10.5′	4½″ & 4″	2	"Exploder." See C. S. Co. report on same, p. 199.	Dana
4.42	Subaqueous	Sandstone	Steam	6′	4½″	2	Edwards Bros. See C. S. Co. report on same, p. 171.	Dana
4.50	Subaqueous	Limestone	Steam	11.0′	4″	2	Dynamiter. See C. S. Co. report on same, p. 206.	Dana
4.86	Subaqueous	Limestone	Steam	8′	3½″	See report on Buf. No. 5	Buffalo Drill Boat, No. 5. See report on same, p. 244.	Dana

*The references in Column 8 are to pages from which this table was taken. These costs were for standard equipment operating under conditions as described at that time. Within the last two years great improvements have been made in drilling machinery so that the newer drills operating at much higher speeds show lower costs.

EXPERIENCE TABLE OF COST OF DRILLING—Continued

5.1	Open cut work	Medium soft shale	Steam	11′	3¼Xbit	2	It was difficult to set up drills on account of much debris, results for two weeks in Mar., 1908. Freezing weather.	Dana
5.30	Subaqueous	Limestone	Steam	14.2	3½″	2	Earthquake. See C. S. Co. report on same, p. 220.	Dana
5.58	Subaqueous	Limestone	Steam	12.1	3½″	2	Hurricane. See C. S. Co. report on same, p. 231.	Dana
6.25	Crushed stone (quarry)	Bastard granite	Air	24′ max.	2½″	2	Duluth Crushed Stone Co. See report on same, p. 132.	Dana
6.45	Open cut work	Soft shale	Steam	11′	3¼Xbit	2	With water jets on drills. Moderately cold, average 20° F. latter part of January.	Dana
6.53	Subaqueous	Limestone	Steam	7.16′ & 8.17′	....	2	No. 4, Buffalo boat. See report C. S. Co. on same, p. 260.	Dana
6.96	Subaqueous	Limestone	Steam	12.5′	4½″ & 4″	2	Destroyer. See C. S. Co. report on same, p. 187.	Dana
6.98	Subaqueous	Limestone	Steam	5.4′	4½″	2	Buffalo No. 1. See report C. S. Co. on same, p. 269.	Dana
7.1	Open cut work	Medium shale	Steam	11′	3¼Xbit	2	Efficient organization sup. extremely cold, varying from 20° to 10°. Much water and ice.	Dana
7.1	Subaqueous	Coral foundation	Steam	10′	....	1 runner ½ helper	See report on Cienfuegos Harbor, Cuba, p. 291	Gilbert
7.14	Subaqueous	Limestone	Steam	10.1′	....	2	Buffalo No. 2. See C. S. Co. report on same, p. 266.	Dana
8.5	Cofferdam, dry	Limestone	Air	4.4-12.7′	3⅞″	2	Cofferdam work. See report, p. 75.	Dana

EXPERIENCE TABLE OF COST OF DRILLING—Continued

8.9	Subaqueous	Soft shale	Steam	6′ 2″	2½″	....	Under 21′ of water in Detroit river.	H. Hodgman
9.7	Open cut	Medium shale	Steam	11″	3¼″X	2	Extremely cold, varying from 20° to 10°; much water and ice. Efficient organization and superintendence.	Dana
10.6	Open cut	Soft shale	Steam	11″	3¼″X	2	Poor supervision; drills in poor shape. Good weather last 10 days of Dec., 1907.	Dana
10.9	Subaqueous	Limestone	Steam	8′ 2″	2¼″X	2	Under 18′ water.	H. Hodgman
11.05	Open cut	Dolomite (L. S.)	Steam	20′	3½″	2	J. A. Hart. See report, p. 115.	Dana
12.5	Tunnel heading	Bastard granite	Air	8′	2¾″	2	N. Y. Water Supply Aqued. See p. 143.	Dana
13.3	Tunnel heading	Bastard granite	Air	6′-10′	3″	2	D. M. Flickwir. See report, p. 100.	Dana
13.5	Open cut	Bastard shale	Air	12′	3½″	2	R. C. & Hill. See report, p. 107.	Dana
9.3 to 17.63	Subaqueous	Limestone and flint; bedrock	Steam	3½′ to 10¾′	....	2	See report on improving Black Rock Harbor, p. 278.	Gilbert
14.4	Crushed stone (quarry)	Hard limestone	Air	12′-26′	4 1/8″-5 5/16″	2	Brownell Impr. Co. See report, p. 125.	Dana
15.0	Subaqueous	Limestone	Steam	5.1″	2½″	....	Under 21′ of water.	Hodgman
16.6	Tunnel	Tough sandstone	....	1½′	⅞″	1	....	Gillette
16.72	Subaqueous	Hard limestone	Steam	1.5-22′	....	2	See report on Hay Lake and Neebish Channel, p. 282.	Gilbert
17.1	Quarry	Hard seamy trap	Steam drill	14′	3¼″	2	....	Gillette
18.4	Subaqueous	Hard limestone	Steam	Av. 6½	....	2	See report on Ship Channel of the St. Lawrence, p. 285.	Gilbert
24.2	Subaqueous	Gneiss, quartz, mica schist	Steam	7′	....	2	See report on Improvements at Oak Point, p. 293.	Gilbert
24.7	Subaqueous	Slate and flint	Steam	5′	....	2	See report on Improving Kennebec river, p. 297.	Gilbert

ELECTRIC AIR DRILLS.

Some of the conditions that particularly favor the selection of this type of drill are as follows:

(1) High altitude, which impairs the efficiency of the ordinary compressor.

(2) Long transmission lines, wire being cheaper than pipes.

(3) Cheap electric power, of the right voltage and frequency.

(4) Badly cracked or faulty rock, which would tend to make the bit stick.

The following table was obtained from a manufacturer:

TABLE 100.

DESCRIPTIVE TABLE OF "ELECTRIC AIR" ROCK DRILLS

Symbol indicating size and type.	5-F	4-E	3-F
Specifications:			
Diameter of cylinder.........in.	5⅝	4¾	3⅝
Length of stroke.............in.	8	7	6¾
Length of drill from end of crank to end of piston.....in.	51½	45	40½
Depth of hole drilled without change of bit...............in.	30	24	20
Depth of vertical holes each machine will drill easily from 1 to ....ft.	20	12	10
Approximate strokes per minute	400	440	480
Diameter of holes drilled as desired from ....in.	1¾ to 2¾	1¼ to 2	1½ to 1¾
Size of octagon steel used....in.	1¼ & 1⅜	1 & 1⅛	⅞
Size of shanks (diameter and length) ....in.	1¼ by 5¾	1 by 5½	⅞ by 5
Number of pieces in set of steels, holes, and depths as stated...	10	6	5
Horse-power required for running drill (at motor).........	5	4	3
Approximate Weights—Drill:			
Drill unmounted, with caps, not boxed ....lbs.	410	228	125
Drill, unmounted, with caps, boxed ....lbs.	485	281	161
Hose, fittings and wrenches, not boxed ....lbs.	65	75	35
Hose, fittings and wrenches, boxed ....lbs.	115	150	65
Tripod, without weights, not boxed ....lbs.	210	170	85
Tripod, without weights, boxed ....lbs.	260	215	120
Tripod weights, not boxed...lbs.	330	265	130
Tripod weights, boxed........lbs.	360	290	150
Entire equipment, including drill, pulsator, alternating current motor, fittings, wrenches and extra parts, but no mountings, steels or blacksmith tools, boxed ....lbs.	1755	1690	925
Entire equipment, including drill, pulsator, direct current motor, fittings, wrenches and extra parts, but no mountings, steels or blacksmith tools, boxed.lbs.	1985	1740	1155

TABLE 100—Continued

Approximate Weights with Pulsator Arranged for Direct Current Motor:			
Pulsator complete, mounted on truck with motor, controller and length of cable, not boxed ....lbs.	1050	950	600
Pulsator complete, mounted on truck with motor, controller and length of cable, boxed.lbs.	1400	1400	850
Pulsator alone, less truck, not boxed ....lbs.	320	320	88
Pulsator alone, less truck, boxed ....lbs.	370	370	125
Motor alone, not boxed.......lbs.	406	390	276
Motor alone, boxed..........lbs.	550	495	330
Armature alone, not boxed..lbs.	90	100	60
Armature alone, boxed......lbs.	120	125	95
D. C. controller, not boxed...lbs.	75	75	53
D. C. controller, boxed......lbs.	110	100	80
Approximate Weights with Pulsator Arranged for Alternating Current Motor:			
Pulsator complete, mounted on truck with motor, controller and length of cable, not boxed ....lbs.	950	950	490
Pulsator complete, mounted on truck with motor, controller and length of cable, boxed.lbs.	1300	1300	625
Pulsator alone, not boxed...lbs.	320	320	88
Pulsator alone, boxed........lbs.	370	370	125
Motor alone, not boxed.....lbs.	356	375	183
Motor alone, boxed..........lbs.	425	490	220
Rotor alone, not boxed......lbs.	80	90	34
Rotor alone, boxed..........lbs.	110	120	50
A. C. controller, not boxed...lbs.	34	34	34
A. C. controller, boxed.......lbs.	50	50	50
Shipping Measurements (overall):			
Box for unmounted drill...ft. in.	4^{0} 1^{4} 1^{4}	3^{10} 1^{2} 1^{2}	3^{6} 1^{1} 1^{6}
Box for pulsator, motor and switch mounted on truck and cable ....ft. in.	4^{0} 4^{0} 3^{2}	4^{4} 2^{3} 3^{10}	3^{0} 3^{0} 2^{4}
Box for hose, fittings and wrenches ....ft. in.	2^{10} 2^{8} 0^{8}	3^{1} 2^{10} 0^{10}	2^{4} 2^{2} 0^{6}
Box for pulsator ....ft. in.	2^{6} 1^{6} 2^{2}	2^{2} 1^{6} 2^{6}	2^{0} 1^{2} 1^{7}
Box for motor ....ft. in.	2^{6} 1^{10} 1^{10}	2^{6} 1^{10} 1^{10}	2^{0} 1^{6} 1^{6}
Box for truck..............ft. in.	3^{6} 1^{0} 0^{9}	4^{2} 1^{0} 0^{9}	2^{7} 2^{0} 0^{10}
Box for armature ....ft. in.	3^{0} 1^{0} 1^{0}	2^{6} 0^{10} 0^{10}	2^{3} 0^{10} 0^{10}
Box for "DC" switch and rheostat ....ft. in.	1^{6} 1^{6} 1^{0}	1^{10} 1^{3} 1^{3}	1^{0} 1^{0} 0^{8}
Box for "AC" controller switch ....ft. in.	1^{5} 1^{0} 1^{0}	1^{4} 1^{1} 1^{2}	1^{2} 1^{0} 1^{0}
Box for tripod............ft. in.	3^{9} 1^{6} 0^{10}	4^{5} 1^{6} 0^{10}	3^{0} 1^{3} 0^{9}
Box for tripod weights.....ft. in.	2^{7} 1^{1} 0^{10}	2^{7} 1^{0} 0^{10}	2^{0} 0^{10} 0^{9}
Price, f. o. b., factory...........	$1,050	$1,000	$750

An excellent general idea of this drill is given by Fig. 86.

The electric air drill is driven by pulsations of compressed air caused by a "pulsator," which is driven by an electric motor. The air is not exhausted, but is simply used over and over again, working backward and forward in a closed pneumatic circuit, from which some leakage of air is necessarily inevitable. This leakage is provided for by compensating valves on the pulsator, adjusted to automatically maintain a constant average pressure in the circuit. The drill is practically a cylinder containing a moving piston and rotation device, without valves chest, buffers, springs, side rods and pawls. The cylinder is larger than that of the corresponding air drill, but the piston is shorter, thus involving no great difference in weight between this and the older types. The pulsator requires no intake and

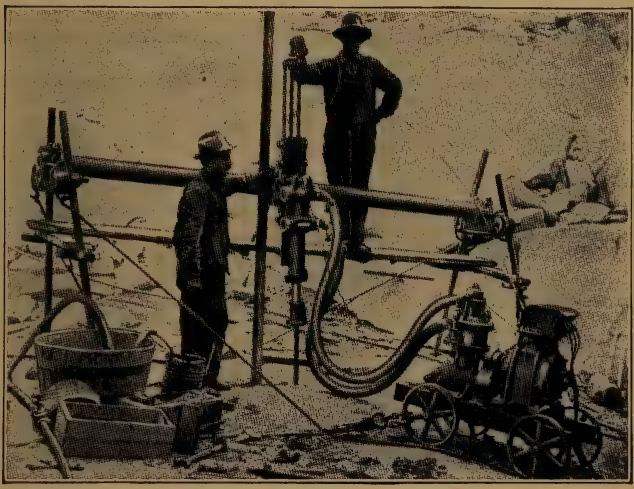

Fig. 86. "Electric Air" Drill at Boutwell Milne and Varnum Quarry, Barre, Vt.

discharge valves nor water jackets. It is geared to a motor which may, of course, be of either direct or alternating current, and is mounted on a wheeled truck for convenience in handling The pulsator and drill are connected by two short lengths of hose, each of which acts alternately as supply and exhaust.

It is claimed by the manufacturer that with the electric air drill there is far less loss of power than in the case of the ordinary air or steam drill, and this claim seems, on theoretical grounds, to be well founded.

The following time studies were taken under my direction on the Kensico dam work at Valhalla, N. Y.:

From these tables an accurate idea can be obtained of the working conditions and performance of these drills.

The holes were vertical.

The rock was for the most part a gneiss, with a tendency toward granite.

It was hard and solid in some places, but in others seamy and presented difficulties to continuous drilling.

The number of holes shot depends upon the progress of the work and at the quarry upon the amount of rock desired for crushing.

Dupont 60 per cent dynamite used.

Sticks 1½" in diameter by about 8" in length, weight 12 oz.

The charge is calculated to average about ½ lb. of dynamite per yard of rock.

Dupont exploders.

Blasting gang at the dam on day of observation, one loader and two tampers.

There were said to be twenty drills at work at the dam and ten at the quarry.

The a. c. motor is rated at about 5 h. p.

The length of shift, eight hours.

One shift per day.

The smith's work consisted of sharpening drills and included also all the work pertaining to other machines on the job. He estimated that 75 per cent of his time was devoted to the drills.

Estimate of coal burned by smith, 500 lbs. per day.

Oil used by drills, 3 quarts each.

Power consumed, from 30 to 40 K. W. H. per eight-hour day

TIME STUDY (QUARRY).

Lineal feet drilled, 31 feet.

Average depth of holes, 22 feet.

Total working time, 7 hours, 27 minutes, 53 seconds.

Rock, gneiss and granite, seamy in places.

TABLE 101—FOLLOWING ARE THE OBSERVATIONS RECORDED IN MINUTES AND SECONDS.

	No. of Obs.	Minimum M—S	Average M—S	Maximum M—S	Actual Time M—S	Consumed Time per cent of Total Time.
Drill cutting........	16	5—40	14—18	23—28	228—54	51.1
Raising drill	15	0—05	1—05	1—59	16—13	3.6
Loosening chuck (1).	7	0—02	0—11	0—45	1—16	0.3
Loosening chuck (2).	3	1—06	1—27	1—46	*4—20	
Removing bit.......	12	0—03	0—32	1—54	6—26	1.4
Bailing hole	11	0—45	1—23	2—00	15—10	3.4
Putting bit in hole.	12	0—10	0—35	0—55	4—20	1.0
Inserting bit in chuck	16	0—10	0—23	0—40	6—12	1.4
Tightening chuck (1)	6	0—05	0—10	0—20	1—00	0.2
Tightening chuck (2)	10	0—38	0—53	1—20	8—46	2.0
Getting started.....	17	0—00	1—01	6—23	17—13	3.8
Cycle totals.....		8—44	21—58	41—30	305—30	68.2
Shifting drill	4	†35—32	52—00	60—00	73—18	16.4
Miscellaneous delays	11	0—30	6—17	25—40	‡69—05	15.4
Total					447—53	100.0

The cutting speed was 0.135 feet per minute.
Ratio of cutting time to total time was 0.511.
Ratio of idle time to cycle time was 0.467.
(1) Sleeve chuck. (2) Bolted chuck.

* This figure is not included in "Cycle Total," for this operation was performed by one man at the same time that the other man was raising the drill.

† Consisted in moving by derrick.

‡ Note the high percentage of delays. Most of these were due to the necessity of waiting until the driller or his helper had gone in search of and had found drill steels. The lack of method in supplying these was one of the noticeable features of the job.

TABLE 102—TIME STUDY (PIT)

Lineal feet drilled, 26.4 feet.
Average depth of holes, 11 feet.
Total working time, 3 hours, 56 minutes, 10 seconds.
Rock, gneiss and granite.

	No. of Obs.	Minimum	Average	Maximum	Actual Time	Consumed Time per cent of Total Time.
		M S	M S	M S	M S	
Drill cutting	12	6—23	11—35	21—24	139—00	58.9
Raising drill	11	0—10	0—51	2—00	9—22	4.0
Loosening chuck ...	12	*0—00	0—09	0—25	1—45	0.7
Removing bit	12	†0—00	0—29	1—10	5—42	2.4
Bailing hole	10	1—43	1—36	2—42	16—01	6.8
Putting bit in hole..	10	0—18	0—45	2—09	7—34	3.2
Inserting bit in chuck	10	0—05	0—25	0—55	4—08	1.7
Tightening chuck ..	11	0—02	0—14	0—40	2—30	1.1
Getting started	10	0—02	0—13	0—45	2—08	0.9
Cycle totals		8—43	16—17	32—10	188—10	‡79.7
Shifting drill	2	9—03	12—00	15—00	28—48	12.2
Miscellaneous delays	8	0—15	2—24	9—40	19—12	8.1
Total					236—10	100.0

The cutting speed was 0.190 feet per minute.
Ratio of cutting time to total time was 0.589.
Ratio of idle time to cycle time was 0.485.

* Chuck loosened by one man simultaneously with raising of drill by other.

† Bit removed by one man simultaneously with raising of drill by other.

‡ The percentage of "Cycle Total" is higher in this case, due mostly to the fact that the drillers were better supplied with steels and did not have to stop work to hunt them. The miscellaneous delays were chiefly due to the bits sticking in the holes.

COST OF DRILLING AND LOOSENING IN GNEISS AND GRANITE.

Based on the above performance at the quarry, the following costs per lineal foot drilled and per cubic yard loosened have been deduced:

1 drill did 31 ft. in 447 min. 53 sec.
Equivalent to 200 ft. by 6 drills in one day.

The average spacing of the holes being 17.5'x16', the corresponding cubic yards loosened=

$$\frac{200 \times 17.5 \times 16}{27} = 2070$$

Dynamite, 60 per cent, 1,035 lbs. or 620 lbs. nitroglycerine, = 0.3 lb. per cubic yard = 3.1 lb. per lineal foot.

STANDARD BASIS OF COSTS.

Force	Rate	Amount		Cost per lin. ft. (Cts.)	Cost per cu. yd. (Cts.)
6 drillers	$2.50	$ 15.00			
6 drillers helpers	1.75	10.50			
			$ 25.50	12.75	1.23
1½ blacksmith	3.00	$ 4.50			
1½ blacksmith helper	1.75	2.63			
2 nippers	1.50	3.00			
2 mules	1.50	3.00			
			13.13	6.57	0.64
Total labor (drill)			$ 38.63	19.32	1.87
Coal, 500 lbs.	3.50	$ 0.87			
Oil, 3 qts. per drill	0.30	1.35			
Power, 35 K.W.H.	0.01	2.10			
			4.32	2.16	0.21
Total drilling cost			$ 42.95	21.48	2.08
3 powdermen	2.00	$ 6.00			
1,035 lbs. dynamite	0.12	124.20			
25 exploders	0.03	0.75			
			130.95	65.47	6.32
			$173.90	86.95	8.40
Interest and depreciation, 2 per cent per month			7.70	3.85	0.37
Total			$181.60	90.80	8.77

In the foregoing no account has been taken of contractor's overhead charges, superintendence, storage, repairs, preparatory costs, insurance, charity, accidents, legal or medical expenses, etc.

The low cost per cubic yard is due to the unusually wide spacing of the holes, which were loaded with a heavy charge of dynamite.

CHURN DRILLS

Churn drills or portable drilling machines are made in about fifteen sizes, some of the largest of which are also built with a traction attachment. The small portable and all the traction machines are usually equipped with a folding pole derrick, which takes up less space than a ladder derrick.

The prices of machines are about as follows:

TABLE 103

Cat. No.	Type of Boiler	Size	Engine H. P.	Derrick	Maximum Drilling Depth	Total Weight Lbs.	Price
15	Vertical	5x 5	5	Hinged pole	250	5,500	$ 687.00
17	Vertical	5x 5	5	Hinged pole	250	6,000	736.00
18	T	6x 5	6½	Hinged pole	300	7,000	847.00
19	T	6x 6	7½	Hinged pole	400	8,500	1,011.00
T19	T	7x 6	9	Hinged pole	400	11,500	1,265.00
20	T	7x 6	9	Hinged pole	500	9,500	1,116.00
T20	T	7x 7	11	Hinged pole	500	13,000	1,377.00
21	T	7x 7	11	Hinged pole	600	10,500	1,200.00
T21	T	8x 7	13	Hinged pole	600	14,000	1,490.00
22	T	8x 7	13	Hinged pole	800	11,500	1,250.00
T22	T	8x 7	13	Hinged pole	800	14,500	1,570.00
23	T	8x 8	15	Single pole	1,000	14,000	1,440.00
T23	T	8x 8	15	Folding pole	1,000	17,000	1,790.00
24	T	9x 8	18	Spliced pole	1,400	16,000	1,568.00
T24	T	9x 8	18	Hinged pole	1,400	19,000	1,948.00
25	T	9x 9	20	Spliced pole	1,600	18,000	1,750.00
26	*T	10x 9	23	Spliced pole	2,200	20,000	1,980.00
27	*T	10x10	26	Spliced pole	2,600	22,000	2,090.00
28	*T	11x10	30	Spliced pole	3,000	24,000	2,200.00

* Mounted on separate trucks.

The letter T in front of the catalogue number indicates that the machine has traction attachment. With the Nos. 26, 27 and 28 machines an "oil country" boiler is better and costs about $100 extra. The prices above include a complete outfit of tools. Rope is also furnished with all machines smaller than No. 23.

Mr. W. G. Weber, in the *Wisconsin Engineer,* describes the use of churn drills in exploring low-grade copper ore bodies in Arizona. A drilling crew usually consisted of one driller and one helper or tool dresser, working in twelve-hour shifts. The costs of operation were as follows:

COST OF DRILLING.

	Cost per Ft. of Hole	
Labor:		
2 drillers at $6 per day	$0.48	
2 helpers at $4.80 per day	.38	
1 sampler at $4 per day	.16	
1 foreman at $6 per day (2 machines)	.12	
		$1.14
Roads:		
Labor at $2 per day	$0.50	
Foreman at $4 per day	.05	
Powder, caps and fuse	.03	
Tools, etc.	.01	
		0.59
Coal, coke, oils, etc.		.27
Water		.10
Teaming		.10
Assaying, office and incidentals, etc.		.16
Interest at 5% and depreciation (life 4 yrs.) on $6,000 outfit		.20
Total cost per foot of hole		$2.56

The monthly average of the cost per foot of hole drilled varies with one company from $2 to $3. In another instance, where holes are drilled further apart and the drilling is poorer the cost per foot has run as high as $5. When drilling is the only means of development being used on a property, the cost of camp maintenance and incidentals considerably swells the cost account.

Mr. H. P. Gillette gives the cost of drilling blasting holes on the Pennsylvania railroad work. The drills used were the ordinary portable churn drills having engines of from 4 to 8 h. p. driving a walking beam which raised and lowered a rope, to which was fastened the churn bit and rods. A 5⅝-inch bit was used in this work. Each drill averaged three 20-foot holes, or 60 feet, in shale per 10-hour shift. In limestone, however, and in hard sandstone, not more than 10 feet of hole were drilled per shift. Had the bits been reduced to 3 inches, and the drill rods suitably weighted, much better progress would have been made in hard rock.

Advantages of Churn Drills

Certain advantages of this type of drill over the regular rock drill are as follows:

(1) A drill will not so readily stick in the hole because of the powerful direct pull of the rope that operates the drill rods; (2) there is no limit to the depth of the hole and the deeper it is (up to any limits possible in blasting) the better the drill works, due to the increased weight of the rods; (3) this type of drill consumes less fuel than the ordinary steam drill; (4) the weight of bits to be carried back and forth from blacksmith shop is much less than for the ordinary machine drills; (5) the driller will drill through the earth overlying the rock, so that no stripping is necessary; (6) the hole at bottom is much larger than with the ordinary drill, thus allowing the bulk of the powder charge to be concentrated at the bottom of the hole, where it should be. For the same reason a lower grade of explosive can be used.

Holes drilled with bits to give 3 inches diameter at the bottom of the hole, with depth of 24 feet, in solid brown sandstone in Eastern Ohio. In 14 days of 10 hours each the driller put down 692 feet, or practically 50 feet per day.

Drill runner	$3.00
Drill helper and fireman	2.00
Pumping water	.60
6 bu. (480 lbs.) coal at 10 cts	.60
Total for 50 ft. of hole	$6.20

This gives a cost of 12½ cents per foot of hole, not including interest and depreciation, and bit sharpening. The best day's work in the brown sandstone, using all the weights, was 53 feet, but in blue sandstone, which was softer, 60 feet were drilled per day, using light weights.

In the same brown sandstone cut an 8-day test was made with a 3¼-inch Rand drill for comparison. The holes were 20

feet deep, 1¾ inches in diameter at the bottom (as against 3 inches with the well driller), and 28 holes were drilled in the 8 days, making 70 feet the average day's work. A 10 h. p. boiler furnished steam. The daily cost of operating the Rand drill was:

Drill runner	$3.00
Drill helper	1.50
Fireman	2.00
Water	.75
10 bu. (800 lbs.) coal at 10 cts.	1.00
Total for 70 ft. of hole	$8.25

This was equivalent to 11.8 cents per foot of hole, not including interest and depreciation, and bit sharpening, or slightly less than with the churn drill.

Mr. William R. Wade, in the *Mining World*, gives some costs of churn and core drilling in exploring for turquoise mines in the Burro Mountains, New Mexico. The machines used cost $4,300, fully equipped and on the work. About 30 feet of 4-inch hole were cut in 8½ hours at a cost of $1.00 per foot, including interest, repairs, superintendence and incidentals. Six barrels of water and ⅜ cord of juniper (equal to pine, cedar or similar soft wood in fuel value) were used per day. Mr. Wade states that with a crew of three men the actual drilling cost about 50 cents per foot, including labor, interest on the drill, supplies and $1.00 per day for repairs, but not including office expenses, superintendence, assaying, etc.

DRILL REPAIRS

In the South African gold mines the cost of drill repairs is about $300 per drill per year, or 50c per shift for two-shift work, and the size of the average drill is about 3¼ inches.

Mr. Thomas Dennison is authority for the statement that the average monthly cost of keeping a drill in repair when working in the Michigan copper mines is as follows:

Supplies	$ 1.31
Machinist labor	8.45
Blacksmith labor	$ 1.60
Total per month	$11.36

Number of drills in shop at one time is about 15 per cent of the total number.

Mr. A. R. Chambers has used 25 Sullivan U. D. drills for 11 months' work in hard red hematite. The holes varied from 6 to 8 feet in depth, and a drilling record of 104 feet was made in one ten-hour shift. The drills were mounted on columns with arms, and the cost of repairs was:

Materials	$5.30
Labor	2.00
Total	$7.30

per month per drill, or about 30 cents per ten-hour day per drill.

Mr. Josiah Bond kept record of drill repairs for three years and they show a cost of $102, $101.50 and $93.75 per year per drill, respectively, for the three years. It is his opinion that a drill used night and day for one year is sufficiently worn at the end of that time to scrap and that its life for single shift work is three years.

Mr. Charles H. Swigert is authority for the following data on tunnel work in very hard basaltic rock. In 9½ months the total of 65,400 feet of hole was drilled, being an average of 29 lin. ft. of hole per drill. The drills were of 3" size. Cost of repairs for four drills was as follows:

Repairs	Per Lin. Ft. of Hole	Per Cu. Yd. Excavated
Labor	0.60 cents	2.80 cents
Material	1.40 cents	6.80 cents
Total	2.00 cents	9.60 cents

The total drill repairs amounted to 58c per eight-hour shift. In the 9½ months 2,262 shifts were worked.

Mr. Hauer states that on one Ingersoll-Sergeant drill of 3⅝" size, class F, the repairs, not including repairs to hose, amounted to $5 per month for a period of four to five months.

I am indebted to Mr. John Rice, vice-president of the General Crushed Stone Co. of South Bethlehem, Pa., for the following information as to drill repairs:

No. of Drills.	Ingersoll - Sergeant Type Drills.	No. Ft. per Year.	No. days.	Average Ft. per Hour per Drill.	Max. Average per Hr. Each Drill.	Min. Average per Hr. Each Drill.	Repairs per Ft. Cents
			Quartzite—1904.				
9	F 9	101,379	1,525	6.65	7.03	6.12	*0.61
			Quartzite—1905.				
8	F 9	118,597	1,383.5	8.57	9.25	7.55	†0.64
			Limestone—1903.				
7	F 9	93,118	922	10.1	10.7	9.37	*0.31
			Limestone—1904.				
7	F 9	114,430	1,130	10.13	11.47	9.32	†0.56
7	F 9	107,837	913	11.8	12.69	10.0	†0.57
			Exceeding Hard Trap—1905.				
5	F 9	36,973	1,411	2.62	3.05	2.58	†1.7
4	A 32	....	.....	.....	2.57	2.24	....

* Drill parts only. † Drill parts, steel and hose.

Note: The Ingersoll-Sergeant drill F 9 has a cylinder 3⅝ ins. in diameter and a 7-in. stroke. The Ingersoll-Sergeant drill A 32 has a cylinder 2½ ins. in diameter and a 5-in. stroke.

Mr. Bond (quoted above) observes that a well-made heavy bar or column should outlast four drills, and arms are generally strong enough to finish three drills. He considers that repairs and depreciation on a stoping drill are about 50c per shift.

The cost of repairs to two Ingersoll drills 3⅛ inches in size at the Melones mine was $91.00 for over 2,600 feet of tunnel.

The following drill repair costs are given in "Rock Drilling," by Dana and Saunders:

The cost for putting in shape for work nine drills on the D., L. & W. cutoff was $1,100. Repairs on fourteen drills for the first 13 months after the commencement of the work amounted to $695.62, or an average of $3.80 per drill per month, or 38 cents per drill per shift.

At Thornton, Ill., the repairs on fourteen drills during nine months in 1909 cost $3,058.47, or 93 cents per drill per day, single shift work.

Fig. 87. Quincey Mining Company's Drill Shop at Hancock, Mich.; Equipped with Four Standard Drill-Making and Sharpening Machines.

DRILL SHARPENING MACHINES

A drill making and sharpening machine, with a capacity for sharpening any sort of drill up to 20 feet in length and 800 to 1,000 bits per eight-hour shift, requires one man to operate the machine and one man to heat the steel. With the machine is furnished one set of dies and dollies for sharpening cross or X bits from 1¼ to 3½ inches gauge. Such a set usually lasts ten months, double shift work. Spares for X bits cost $75.00. Compressed air at 80-90 lbs. is used for the pistons, and a small motor or other drive for the drill rest. About $100 per year will cover repairs to the machine. The price, f. o. b. N. Y., is $1,350, the net weight about 5,000 lbs., and shipping weight 6,000 lbs.

One drill sharpening machine was operated by one man who attended his own forge and made necessary repairs. It ran on

an average of 4 hours per day and sharpened approximately 36,000 drills, averaging 50 drills per hour. The amount of fuel used was about one-half that required in hand work. To form and sharpen new drills required 1½ minutes. The life of a bit sharpened by this machine is longer than when done by hand, the bits being better compacted, and drills can be sharpened at the same machine by the same dies. Before this machine was used two blacksmiths and two helpers were necessary, the machine showing a saving over hand labor in 6 months of $1,738.50 and saving in coal for 183 days, $83. Total saving for 6 months, $1,821.50. (No record as to machine cost.)

In the South African gold mines each drilling machine uses an average of twenty drill points per shift, which amounts to 600 lbs. of drills removed to and from the job for each machine

Fig. 88. Drilling "Up" Holes with the "Little Imp" Air Feed Drill.

Fig. 89. Drilling "Down" Holes with the "Little Imp" Drill.

per shift. One blacksmith with a helper will keep 5 to 7 drills supplied with sharp bits. In medium rock a bit must be sharpened for each 2 ft. of hole, in hard rock, for each 1½ ft., and in soft rock for each 4 ft. The direct cost of sharpening bits by hand is about as follows:

Blacksmith	$3.00
Helper	2.00
Charcoal	.60
Total ....140 bits at 4 cents =	$5.60

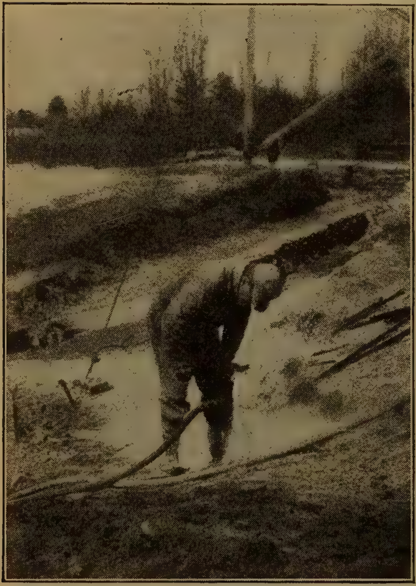

Fig. 89 A.

Mr. T. H. Proske says:

"The power drill-sharpener has removed many of the shortcomings attendant upon the hand sharpening process, with the result that where these machines are used it is possible to accomplish from 25 to 100 per cent more drilling than under the old methods." I take this to mean 25 to 100 per cent more drilling per trip to the shop on the part of the drill tender, which statement is well within the facts. Especially is this true when the machine sharpening is combined with the selection of special drill steels.

HAND HAMMER DRILLS

Hand Hammer Drills are light, powerful, small tools which are adapted to light work in mines and quarries.

Imperial Hand Hammer Drill No. MV2, complete	$60.00
1 drill, 12-inch	1.15
1 drill, 24-inch	1.55
1 drill, 36-inch	2.00
1 drill, 48-inch	2.50
1 dolly	2.50
25 ft. of ½-inch, 7-ply air hose complete	7.20
Total	$76.90

Performance of Small Hand Hammer Drill

The writer examined with some care the operation of a small hand hammer drill in the field operating in granitic schist in a New Hampshire quarry. The accompanying photographs, Figs. 89A and 89B, show the drill in operation with the dust coming out

of the hole and being carried away by the wind; and the operator in the act of releasing drill steel from the chuck. This operation of changing steels required an average of 11⅕ seconds on the part of a highly skilled operator. The field notes of this test were as follows:

	Time		
	Hours	Minutes	Seconds
Start of first steel	1	42	3
Finish of first steel	..	43	25
Start of second steel	..	43	37
Finish of second steel	..	44	54⅗
Start of third steel	..	45	5½
Finish of third steel	..	46	20
Start of fourth steel	..	46	31⅗
Finish of fourth steel	..	47	20⅕
Start of fifth steel	..	47	13⅘
Finish of fifth steel	..	48	22½

Total depth of hole, 55⅛ in.
Average depth per steel, 11 in.
The steel used was ⅞-in. hexagonal hollow rolled steel.
First bit, diameter, 1¾ in.
Last bit, diameter, 1¼ in.

Fig. 89 B.

After the hole was finished, dust filled the hole to about a depth of 8 in. until blown out, which time for blowing out is not included in the above time study. The elapsed time for the entire operation was 6 min. 19⅕ sec., or 6.32 min. The total time to change steels was 44⅘ sec., or .75 min., making 5.57 min. for drilling time, or practically 10 in. per minute. This, of course, did not include the time of getting ready for a new hole or blowing out the old hole, both of which operations could easily be accomplished in 30 seconds by an average operator. This example is given to show the adaptability of these small hand machines for rapid and economical work on comparatively shallow holes. In addition to the air pipe is shown a pipe running to the pressure gauge, which registered 102 lbs. when the drill was not working and 85

lbs. with drill running. The former pressure represented the pressure at the compressor. In this drill some of the exhaust goes down through the bit and blows the rock cuttings up out of the hole, producing a heavy cloud in a strong wind.

SUBMARINE DRILLS

There are two general methods of submarine drilling: (1) "Platform Method," so-called from a platform or staging supported on "spuds." This method is applicable where currents are excessively disturbing influences. (2) The "Barge Method" employs a floating scow or barge carrying the drills and other equipment, anchored in place by cables or chains. The height of the framing, length of feed, etc., and resulting price of equipment, depend upon depth of drilling.

A number of plants for subaqueous drilling are described in "Rock Drilling," by Dana and Saunders, from which the following data are abstracted:

The Platform Method. Cylindrical telescopic tubes with a conical taper, fitted with an ejector attachment, rest on the rock, with upper end above the surface of the water. Drilling, washing and charging are performed through these tubes. The use of the water jet is usually very economical. The boilers, shops, pumps, diving apparatus, etc., are usually carried by barge or scow moored to the platform and by anchors.

In the operations on Black Tom Reef, New York harbor, which commenced May 2, 1881, 344 actual working days were occupied in drilling 1,736 holes, a total of 17,658 lineal feet (av. depth 10.17′) and removing 5,136 cu. yds.

The cost of plant, including alterations and additions, was as follows:

Barge No. 4, hull and equipment	$ 6,640.00
Drill Float, No. 1	4,095.70
Drill Float No. 2	4,987.40
Machinery, etc.	3,815.51
Total	$19,538.61

The foregoing cost of plant and the following cost of operation are excessive, due to the experimental work prior to the introduction of the improved methods of operation.

The operating expenses were as follows:

	Total Cost	Cost per Lin. Ft. Drilled	Cost per Cu. Yd. Removed
Labor	$ 9,203.88	$0.521	$1.792
Explosives	9,461.00	0.535	1.844
Actual repairs to plant	1,575.57	0.089	0.307
Repairs to drills	93.31	0.005	0.018
Repairs to ejector pipes	267.54	0.015	0.052
Steam and water hose	491.18	0.028	0.096
Connecting wire, 77¼ lbs.	52.08	0.003	0.010
Rubber tape for connections, 7 rolls	12.25	0.001	0.002
Water	500.55	0.029	0.096
Coal, 200.2 tons	823.03	0.047	0.160
Total	$22,480.39	$1.273	$4.377

Area drilled over	32,100	sq. ft.
Dynamite used	20,461	lbs.
Exploders used	1,844	
Number of drilling machines	3	
Steels used (octagon 1 1/12")	18	
Total loss of steel by abrasion and dressing (59.5')	394.5	lbs.
Average depth of hole to each cu. yd. rock removed	3.44	lin. ft.

Barge Method. The drill boat used by the Great Lakes Dredge Dock Co. at West Neebish Channel, St. Mary's River, in 1909, was of timber, 126 ft. long by 30 ft. beam, covered by a house in which were boilers, shops and men's quarters. The equipment included the following:

1 Scotch marine (3 fire) boiler, 14' long x 13' diameter.
1 Each blacksmith's forge, anvil, block with stack, bench, vise, pipe clamp.
17 Span drill bits.
1 Hydraulic cylinder, 12"x15' 6", with 3½" piston and traction chain for moving drills.
1 Small feed pump.
2 Force pumps.
1 dynamo (and switchboard) driven by one cylinder belted engine; dynamo 110 volts and 42 amperes, D. C., 5 h. p., 1,600 r. p. m.
1 Small vertical washout boiler.
5 Drill machines, 6½" on track of 2' 6" I beams.
2 Steam driven capstans.
4 Spud engines, 6"x6½".

The cost of the plant was approximately $35,000.00.

The drill boat "Earthquake" used by Dunbar and Sullivan on Section No. 3 of the Livingstone channel, Detroit River channel improvement, had a steel hull 106 ft. long, 30 ft. wide and 5 ft. 9 in. deep. The deck was of 2-in. planking, and the house, 89x19x13 ft. high, also of wood. The framework of the hull was composed of standard angles and brackets, and divided into four watertight compartments by transverse bulkheads.

The equipment includes the following:

4 Drills and equipment.
4 Spud anchors.
4 Spud anchor engines.
2 Steam capstans.
17 Bits.
1 Hydraulic cylinder, 11 ft. long x 12 in. diameter for shifting drills.
1 Boiler, 12½x7½ ft.
1 Feed water heat.
1 Injector.
1 Small engine for boiler feed.
1 Small pump for washout.
1 Pump, 10x7x10 in., for hydraulic lift.
1 Each anvil, forge, bench, vise and pipe clamp, small blower and blower estimate.
1 Dynamo and small engine for lights.
1 Tank, 7x21x3 ft., for heating feed water for hydraulic lift in winter.
1 Cutter and 1 powder boat.

The cost of the plant was approximately $45,000.

On the Hay Lake and Neebish Channels improvement of St. Mary's River, Mich., Section No. 4, the following plant was used:

3 Drill boats, approximate value	$ 34,000
2 Dredges, approximate value	45,000
4 Dump scows, approximate value	30,000
1 Floating derrick, approximate value	6,000
2 Tugs, approximate value	10,000
Total	$125,000

The drill boats have wooden hulls, 98x25x6 ft., 90x30x6 ft. and 65x16x5½ ft, the two largest having 3 drills each and the smaller 2 drills.

The following tabulation of the cost of subaqueous drilling is also abstracted from "Rock Drilling":

TABLE 104

Actual drilling labor per ft. of hole (cents)	Kind of Rock	Kind of Drill	Depth of Hole (ft. and in.)	Starting bit (inches)	No. of men to drill	Remarks.	Authority
1.62	Sandstone	Steam	7-0	4¾	2	Great Lakes Dredge Dock Co., Boat No. 5.	Dana
						West Neebish Channel	
3.53	Limestone	Steam	10-6	4½ & 4	2	"Exploder"	Dana
4.42	Sandstone	Steam	6-0	4½	2	Edwards Bros.' Boat	Dana
4.50	Limestone	Steam	11-0	4	2	"Dynamiter"	Dana
4.86	Limestone	Steam	8-0	3½	..	Buffalo Boat No. 5	Dana
5.30	Limestone	Steam	14-0	3½	2	"Earthquake"	Dana
5.58	Limestone	Steam	12-1	3½	2	"Hurricane"	Dana
6.53	Limestone	Steam	7-2 & 8-2	...	2	Buffalo Boat No. 4	Dana
6.96	Limestone	Steam	12-6	4½ & 4	2	"Destroyer"	Dana
6.98	Limestone	Steam	5-4	4½	2	Buffalo Boat No. 1	Dana
7.1	Coral	Steam	10-0	...	1 runner & ½ helper	Cienfuegos Harbor, Cuba	Gilbert
7.14	Limestone	Steam	10-1	...	2	Buffalo Boat No. 2	Dana
8.9	Soft Shale	Steam	6-2	2½	..	21′ Water, Detroit River	H. Hodgman
10.9	Limestone	Steam	8-2	2¼	2	18′ Water	H. Hodgman
9.3 to 17.63	Limestone and Flint	Steam	3-6 to 10-9	...	2	Black Rock Harbor	Gilbert
15.0	Limestone	Steam	5-6	2½	..	21′ Water	Hodgman
16.72	Hard Limestone	Steam	1-5 to 22-0	...	2	Hay Lake and Neebish Channel	Dana
18.4	Hard Limestone	Steam	Av. 6½′	...	2	Ship Channel, St. Lawrence	Gilbert
24.2	Gneiss, Quartz, Mica Schist	Steam	7-0	...	2	Oak Point, East River	Gilbert
24.7	Slate and Flint	Steam	5-0	...	2	Kennebec River	Gilbert

MISCELLANEOUS DRILLS

CHANNELERS.

These machines are used generally where the output of quarries consists of dimension stone, but sometimes, as on canal work, it is more economical to channel rocks to a required face than to drill and blast beyond the "pay" limit. Another definite advantage in the use of channelers is noted in the building of the Chicago Drainage Canal, where the walls were required to be left smooth and solid. The depth to which a channeler can cut depends upon the character of the rock. A cut as great as 17 ft. has been accomplished, but very rarely. The general average is from 7 to 10 ft. With a 9 ft. cut in shale, a machine under my direction, in February, 1908, cut from 80 to 250 sq. ft. per day of three shifts with a total of 3,139 sq. ft. for the month. The width of a channel cut will vary with the conditions from 1½ in. to 5 in., more or less. The cost per square foot channeled was 13.5 cents labor and about 4 cents for coal. These costs are exclusive of plant, superintendence and overhead charges.

In the fixed-back channeler the movement of the steels is limited to two vertical planes and the cut is vertical with square ends. The swing-back track channeler is intended for angular cutting in quarries where the floor is to be enlarged. And it is desirable to follow it without removing overlying rock. The Broncho channeler has a purpose intermediate between the heavy track channeler and the light quarry bar and drill. The undercutting track channeler is designed to meet conditions in rock in which there are no free horizontal beds, and the cleavage of the stone is nearly vertical.

TABLE 105—SPECIFICATIONS OF CHANNELERS

Size and Type		Unit	Fixed Back Channeler "H8"	Swing Back Channeler and 6-in. Ram	Undercutting Channeler
Diameter of cylinder		in.	8	6	3½
Length of stroke		in.	9	6½	6½
Distance of cut from Vertical wall		in.	7¼	7¼	8½ (lift)
Distance from center to center of cut with machine reversed		ft. in.	7—0	4— 7½	
Inside gauge of track		ft. in.	5—3	3— 0⅝	4—0⅜
Length over all		ft. in.	6—0	5— 5	7—5
Width over all	Without boiler	ft. in.	7—8½	5— 5	8—3
	With boiler	ft. in.	8—1½		
	With reheater	ft. in.	7—8½		
Height	Without boiler	ft. in.	7—8	6—10½	3—2
	With boiler	ft. in.	10—9		
	With reheater	ft. in.	7—8		
Weight of Channeler alone	Without boiler	lbs.	7,720	5,150	4,100
	With boiler	lbs.	13,750		
	With reheater	lbs.	11,360		
Total shipping weight with track and equipment	Without boiler	lbs.	† 14,850	† 10,500	‡ 7,600
	With boiler	lbs.	20,875		
	With reheater	lbs.	18,500		
Approximate price, f.o.b. Factory	Without boiler		$2,500	$2,090	See Note
	With boiler		2,900	2,365	
	With reheater		2,600	2,290	

Note: Price of Undercutting Channeler; HF3, 1-shell, $1,450; HF3, 2-shell, $1,560; HF4, 1-shell, $1,200; HF4, 2-shell, $1,210.

* Height is from top of rail to top of boiler hood which does not include stack.
† These weights are for domestic shipment. Add 1,000 lbs. for foreign shipment.
‡ This weight is for domestic shipment. Add 500 lbs. for foreign shipment.

Standard track equipment furnished with channelers provides for a total length of forty-two feet in three sections. Eighty-pound rail is used. A tool chest with a very complete equipment, boiler tools, etc., is supplied.

Steels are furnished according to the stone to be channeled, as follows: They cost about $2.50 per foot per gang or $5 per foot per set of 2 gangs.

Steels for Marble and Limestone When Used with Crosshead.

Fifty pieces of steel constitute two sets (10 gangs, 5 pieces to each gang), to channel to a depth of 7 ft. in marble and limestone. Size of steel, ⅞ in. by 1½ in.

2 Gangs—10 pieces, each 1 ft. 6 in. long
2 Gangs—10 pieces, each 3 ft. "
2 Gangs—10 pieces, each 4 ft. 6 in. "
2 Gangs—10 pieces, each 6 ft. "
2 Gangs—10 pieces, each 7 ft. 6 in. "

The Blacksmith's Gauge for Steels for Marble and Limestone commences at 1½ in. and reduces 1-16 in. on each length from the 3-foot lengths up. The starters and the 3-foot lengths have the same gauge, 1½ in.

All gangs of the same length have the same gauge.

Steels for Sandstone When Used with Crosshead.

Thirty pieces constitute two sets (10 gangs, 3 pieces to each gang), to channel to a depth of 7 ft. in sandstone. Size of steel, ⅞ in. by 2½ in.

2 Gangs—6 pieces, each 1 ft. 6 in. long
2 Gangs—6 pieces, each 3 ft. "
2 Gangs—6 pieces, each 4 ft. 6 in. "
2 Gangs—6 pieces, each 6 ft. "
2 Gangs—6 pieces, each 7 ft. 6 in. "

The Gauge for the Sandstone Bits commences at 3 in. and reduces ¼ in. on each length from the 3-foot lengths up. The starters and the 3-foot lengths have the same gauge, 3 in.

All gangs of the same length have the same gauge.

Steels for Marble and Limestone When Used with Roller Guide.

Fifty pieces of steel constitute two sets (10 gangs, 5 pieces to each gang), to channel to a depth of 7 ft. in marble or limestone.

Each gang uses 3 steels 1 in. by 1⅜ in. and 2 steels 1 in. by 1¼ in.

2 Gangs—10 pieces, each 2 ft. 6 in. long
2 Gangs—10 pieces, each 4 ft. "
2 Gangs—10 pieces, each 5 ft. 6 in. "
2 Gangs—10 pieces, each 7 ft. "
2 Gangs—10 pieces, each 8 ft. 6 in. "

Note: It will be noticed that these steels are longer for a given depth of cut than when a crosshead is used, but this extra length is used by Roller Guide.

The Blacksmith's Gauge for Steels for Marble and Limestone commences at 1½ in. and reduces 1-16 in. on each length from the 4-foot lengths up. The starters and the 4-foot lengths have the same gauge, 1½ in.

GADDER.

The Gadder is used to drill a number of parallel holes in a plane, at any angle from horizontal to vertical, or, in connection with the channeler, in drilling the horizontal undercutting holes. In "plug and feather" work it is used to break the large blocks cut free by the channelers.

The equipment includes the following: One truck with corner pins, 1 standard back screw, 1 long back screw and extra short back screw for frame, 1 set of oilers, 1 set of wrenches, 1 tie rod 8 ft. long. Price of gadder frame $465, f. o. b. factory; weight 2,550 lbs. Price of drill (extra) 36 in. feed, $165. Approximate shipping weight of frame and drill complete, 3,150 lbs.

QUARRY BARS.

Size	Length of Bar (over all) Ft.	In.	Length of Cut Ft.	In.	Size of Drill Suitable for Inches	Weight Without Drill or Weights Lbs.	Shipping Weight Without Drill or Weights Lbs.	Shipping Weight Without Drill But With Weights Lbs.	Price, f. o. b. Works
Light 3-inch	10	0	8	4	2 2¼ *2½	480	565	945	$150.00
Standard 4½-inch	12	0	10	0	*2¼ 2½ 2¾ 3 3¼ 3½ 3⅝	960	1,125	1,625	$187.50

Complete Quarry Bar includes carriage, weight and wrenches, but no drill.

* When a 2½-inch drill is used on the 3-inch Light Quarry Bar, or a 2½-inch drill is used on the 4½-inch Standard Quarry Bar, a special saddle is necessary.

ELECTRIC AIR CHANNELER.

This machine is operated on the same principle as the electric air drill heretofore described.

The character of current recommended is the same as for the electric air drill.

Equipment.

One complete "Electric-Air" Channeler outfit includes the following:

One "Electric-Air" Swing Back, Swivel Head Track Channeler mounted on a rigid cast iron truck with single flanged truck wheels.

One pulsator rigidly mounted on the truck; one motor, either 220 volt direct, or 220 volt, 3-phase, 50 or 60 cycle, alternating current; and one speed-changing controller.

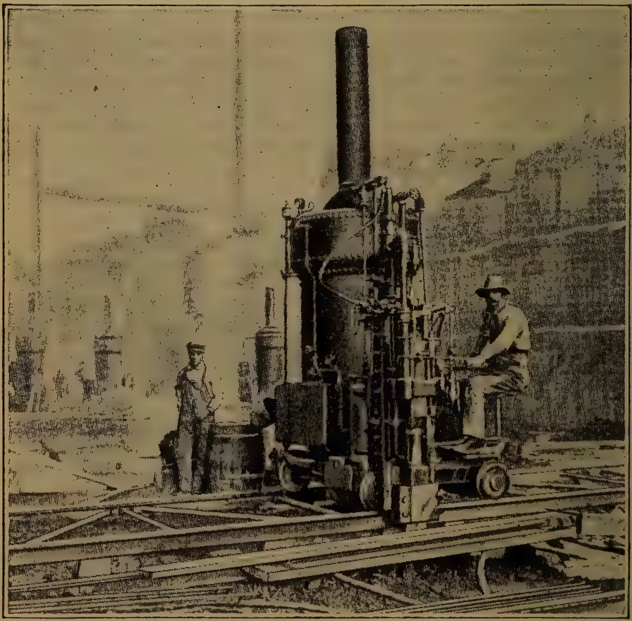

Fig. 90. Track Channelers in Operation in the Quarries at Bedford, Indiana.

In addition to the above the following accessories are provided: 30 feet of flexible protected cable with connections; one drag pole; three 12-foot sections of track and one 6-foot section; one set of lifting bales; one spare chuck clamp; one main fuse box; a full set of wrenches; a full set of tools; and selected extra parts covering both the mechanical and electrical parts of the equipment. Channeler steels are furnished only on order, at extra cost.

Price, complete, $4,250 net, f. o. b. factory.

When requesting quotations on rock drilling machinery, the following information should be furnished the manufacturer:

In Quarrying.

1. Give the location of work, whether on surface or underground.
2. Describe the nature of the rock, whether sandstone, slate, limestone, granite, marble, etc. State whether the material is hard, medium or soft.
3. Is the quarry output in dimension stone or simply broken rock?
4. If the material is shelly, state whether it is tight or loose.
5. What is to be the extreme depth of holes? Are there many or few of these deep holes?

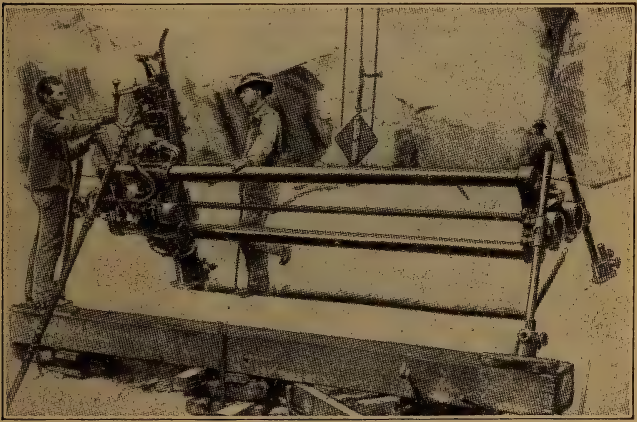

Fig. 91. The "Broncho" Channeler on a Side Hill at the Waverley Marble Quarries, Tuckahoe, N. Y.

6. What is the average depth of the holes to be drilled? (This is important.)
7. What is to be the average diameter of the holes at the bottom? If undecided, state whether dynamite or black powder is to be used.
8. What is the greatest distance to which steam will have to be piped or will ever be used?
9. A rough sketch of the quarry is very useful and also a small sample of the material to be quarried. If the latter is sent, it should be properly labeled with the name and address of the sender and prepaid; a 3-inch or 5-inch cube is a good size.

In Railway Cut or Excavation.

10. Give the full dimensions of the cut and in addition answer such questions in above list as may apply to the case.

In Sewer or Trenching Work.

11. Give answers to questions Nos. 2, 4, 6, 7, 8 and 9 above.

12. Give the width and depth of the trench, stating the depth of the rock which is to be removed, and depth of earth (if any) over the rock.

In Metal Mining.

13. Give full information as to the nature and quality of the ore.

14. Describe the general system of mining.

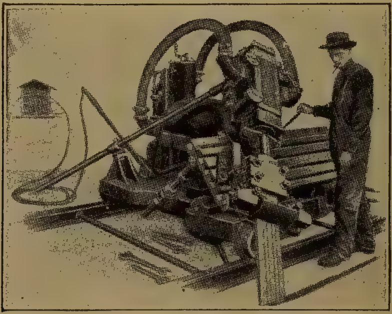

Fig. 92. Front View of the "Electric-Air" Channeler, Showing It Adjusted for Making a Transfer Cut.

15. Give the dimensions of the shafts, drifts, stopes and winzes which are to be driven.

16. If a compressed air equipment is desired, answer the questions under the heading of "Compressed Air."

In Tunneling.

17. What is the nature of the material which is to be passed through?

18. Dimensions of tunnel?

19. What is to be the total length?

20. Are heading and bench to be driven together, or will a heading be driven first and the bench removed afterward?

21. Is the tunnel to be driven from one end only, or from both?

22. Are intermediate shafts to be sunk? If so, give their depth and cross-section, and describe the material to be penetrated.

23. If compressed air is to be used, distributed by pipes leading from a central station, these stations should be located where coal and water are most readily accessible. In such cases answer the questions under the heading "Compressed Air."

In Shaft Work.

24. What are to be the dimensions of the shaft?

25. Give the depth proposed and nature of the rock or ore penetrated. If compressed air is to be used, answer the questions under that head below.

In Submarine Drill Work.

26. Give the greatest depth of water over the rock to be excavated.

No. 93. No. 11 "Imperial" Wood Boring Machine.

27. Give the depth of rock which is to be blasted and the depth of the holes to be drilled. If possible, state a maximum and minimum depth required.

28. Give the rise and fall of the tide, if any.

29. Give the velocity of the current, if any.

30. State whether the drilling is to be done from a scow, pontoon, platform or whatever support is used.

31. State whether the rock is covered with mud, clay, gravel or sand, and if so, to what depth.

Where Compressed Air Is to Be Used.

32. State the altitude above sea level at which the compressor is to be located.

33. Give a general idea of the location and arrangement of the plant.

34. State how near the plant is to fuel and water, and the kind and cost of the fuel.

35. State how far the compressing plant is from the work to be done.

36. If other machinery than drills is to be run by air, give the cylinder dimensions, the speed, the pressure necessary, the running time, the location, and other information likely to be of service.

37. State whether the compressor is to be run by steam, electricity or water power.

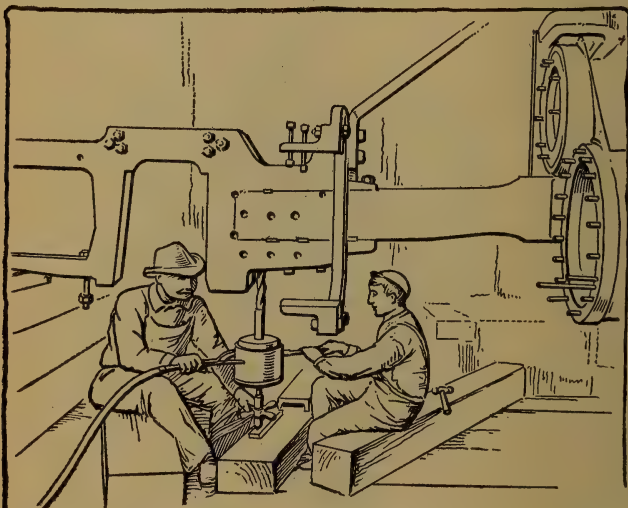

Fig 94. Drilling Frame Bolt Holes in a Locomotive Frame.

38. Give the steam pressure which is to be used.

39. State whether the compressor is to run condensing or non-condensing. If condensing, state quality, temperature and quantity of water available.

40. If a boiler is already available, state its rated horse-power.

41. State how long the work is to last, and whether the most economical or a cheaper plant is contemplated.

42. If electric power is to be used, state character, voltage and frequency of current available.

43. If water power is to be used, state head and quantity available.

44. If compressor must be sectionalized, state limit of weight permissible.

PNEUMATIC PISTON DRILLS.

Pneumatic piston drills are used for drilling metals, boring wood, tapping, reaming, flue rolling, etc. The No. 1 and No. 11 machines listed below cost about $72.00 and the other sizes about $75.00.

TABLE 106

Style	Size	Weight (Lbs.)	Length (Ins.)	Length of Feed (Ins.)	Diameter from Side to Center of Spindle (Ins.)	Morse Taper Socket (Ins.)	Square Tap Socket (Ins.)	Size Twist Drill Will Drive (Ins.)	Size of Wood Bit Will Drive (Ins.)	Reaming (Ins.)	Tapping (Ins.)	Flue Rolling (Ins.)	R. P. M. at 80 Lbs.	Cubic Feet of Free Air at 80 Lbs.	Hose Connection (Ins.)
Not reversible	2	48	20 5/8	4	4 3/8	3	9/16	1 1/4		1	1		290	25	3/4
Not reversible	3	52	22 3/4	4	4 3/8	4	9/16	2 1/4		2	2		290	35	3/4
Reversible ...	1	27	19 5/8	3	3 5/8	3		1		3/4	3/4		220	20	1/2
Reversible ...	4	70	23 1/4	4	5 1/4	4	9/16	3		2 1/2	2 1/2	4	170	45	3/4
Reversible ...	11	27	14 1/3		3 5/8				2 1/2				350	20	1/2
Reversible ...	12	48	20 5/8	4	4 3/8	3	9/16	1 1/4	4	1	1	2 1/2	275	25	3/4
Reversible ...	13	52	22 3/4	4	4 3/8	4	9/16	2 1/2		2	2	3	235	35	3/4
Reversible ...	21	27	19 5/8	3	3 5/8	2		7/8		1/2	1/2		350	20	1/2

SAND PUMPS.

"Down" holes in rock forming a mud which will not splash out must be cleaned at intervals—usually at every change of steels. For this purpose the sand pump is used. It is a section of wrought iron boiler tube having a valve at its lower end which opens to admit the slush, but closes when the tube is lifted. At the upper end of the tube a chain should be attached, made up of several links of rod by which the pump is forced to the bottom of the hole. A ring at the last link prevents the chain from dropping in the hole. The two-foot length is used for cleaning holes without moving the drills; greater lengths are intended for deep holes. Standard sizes and prices are tabulated below.

TABLE 107—SAND PUMP WITH BAIL

Outside Diam. in ins.	No. 1 $1\frac{1}{16}$-inch	No. 2 $1\frac{5}{16}$-inch	No. 3 $1\frac{11}{16}$-inch	No. 4 $1\frac{15}{16}$-inch	No. 5 $2\frac{3}{8}$-inch
Standard Sizes Ln.	Price	Price	Price	Price	Price
In stock 2 ft....	$1.00	$1.00	$1.25	$1.50	$2.50
In stock 4 ft....	1.50	1.50	1.75	2.00	3.00
To order 6 ft....	2.00	2.00	2.25	2.50	3.50
For each additional foot of length add	.25	.25	.25	.30	.30

Note: Above prices are for pump complete with valve and bail, but do not include a chain or rod.

Net price for stone drills at Boston is as follows: Stone drills, 1 and 1⅛-in. octagon steel, 2 to 6-ft. lengths, 12 cts. per lb.

The net prices at Chicago for hand drills for stone, marble and granite are as follows: Ball drills, 7 ft. long, 8 lbs. weight, $2.85 each.

TABLE 108—MISCELLANEOUS DRILLS

	Each	Per Doz.
¼-in.x 8-in.	$0.30	$3.00
⅜-in.x10-in.	.35	3.60
½-in.x12-in.	.40	4.00
⅝-in.x14-in.	.45	4.50
¾-in.x16-in.	.60	6.00
⅞-in.x16-in.	.70	7.20
1-in.x16-in.	.75	7.50

Net price for drills is as follows: Stone drills, 1 and 1⅛-in. octagon steel, 2 to 6 ft. lengths, 12 cts. per lb.

Blacksmith drills operated by hand power, for drilling holes up to 1½ ins., weigh from 90 to 150 lbs., and cost from $12.00 to $25.00.

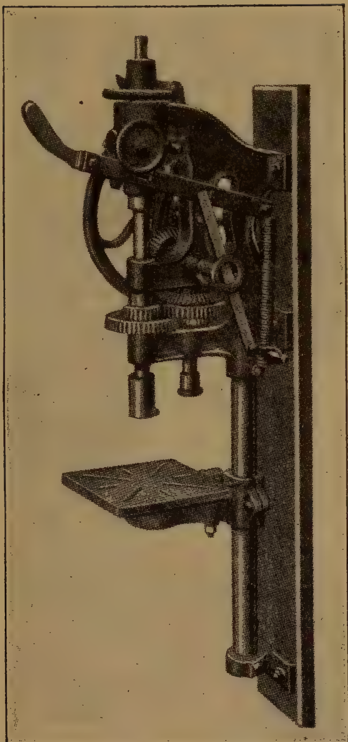

Fig. 95.

ELECTRIC GENERATORS

An electric light plant with generator driven by a gas engine of special design has the following specifications:

Direct connected sets:

TABLE 109

H. P.	R. P. M.	No. of Cylinders	Wt. of Engine	Generator	Capacity in 56 Watt Lamps	Wt. of Generator (Lbs.)	Total net Wt. Inc. (Lbs.)	Price
8	350	1	2,200	5½ K. W.	80	950	3,925	$ 855
10	350	1	2,600	6½ K. W.	100	1,000	4,375	945
12	335	1	3,000	7¾ K. W.	125	1,300	5,350	1,080
18	325	2	4,000	12 K. W.	180	1,950	7,050	1,485
25	325	2	5,000	18 K. W.	250	2,100	8,425	1,800
35	300	2	7,000	27 K. W.	350	2,800	11,500	2,430

The shipping weight is about 500 lbs. more than the total net weight. Regular equipment consists of rheostat, muffler, spark coil, ignition wire, wrenches, and gas regulator with gas engines.

The following are excerpts from records of tests made in actual service:

TABLE 110—I

	Test Made at Albany, N. Y., 12 H. P. Direct Connected to 7¾ K. W. Generator.	Test Made at Pittsburgh, Pa., 25 H. P., Belted to 22 K. W. Generator.	Test Made at New York City, 10 H. P. Direct Connected to 6½ K. W. Generator.
Fuel	Manufactured gas	Natural gas	Gasoline
Value of fuel	600 B. T. U. per cu. ft.	1,100 B. T. U. per cu. ft.	78° gravity
Cost of fuel	$1.00 per thousand ft.	27½ cents per thousand ft.	14c per gal.
Duration of test	5 hours	5 hours	2 hours
Amperes	65	128	50
Volts	120	111	119
Fuel consumed per hour	260 cu. ft.	303 cu. ft.	11.25 pints
Cost of fuel consumed per hour	26 cents	8 3/10 cents	19.7 cents
Cost of fuel per K. W. H.	3⅓ cents	$0.0057	$0.033
Cost per hour per 60 watt lamp	$0.002	$0.00034	$0.002
Efficiency of generator	80%	85%	78%
H. P. developed by engine	13	26	10.2
Temperature cooling water discharge	162° F.	175° F.	170° F.
Temperature of room	86° F.	85° F.	88° F.
Temperature of generator at end of test	132° F.	110° F.	105° F.

Where economy of space is not necessary, belted sets may be installed at a saving in first cost.

II

BELTED PLANTS.

Engine			Generator				
H.P.	R.P.M.	Price.	K.W.	Capacity in 56 Watt Lamps.	R.P.M.	Size of Pulley.	Price.
1½	400	$ 70.00	⅞	15	1,200	6"x 3½"	$ 88.00
2½	400	90.00	1½	25	1,600	6"x 3½"	88.00
5	375	160.00	3	54	1,600	7"x 4"	108.00
6	375	216.00	3½	63	1,600	7"x 4"	116.00
8	350	400.00	5⅛	80	1,100	9"x 5"	174.00
10	350	475.00	6½	100	1,350	9"x 5"	174.00
12	335	550.00	7¾	125	700	12"x 6"	235.00
18	325	800.00	12	180	1,150	10"x 5½"	239.00
25	325	900.00	17	250	900	16"x 8"	333.00
35	300	1,300.00	275	350	680	20"x12"	488.50

All engines are guaranteed to carry a 10 per cent overload.

ELECTRIC MOTORS

Electric motors used by contractors in general construction work range in size from a fraction of a H. P. to about 150 H. P. Direct current motors may be furnished shunt, series or compound wound. Shunt wound motors maintain a perfectly constant speed regardless of load. They are used when constant speed is required under changed loading conditions and are particularly suitable for driving line shafting or groups of machines operated by one motor. Series wound motors vary in speed in proportion to the load carried. They exert a very strong start torque and will race if allowed to run free. They are particularly suitable for operating cranes, hoists, etc., where frequent reversals are necessary and where the speed of the motor is constantly under the control of an operator.

Compound wound motors combine the advantages of the shunt and of the series wound motors. They will vary in speed under changed loading conditions more than a shunt wound motor, but they will not race nor slow down under a heavy load to such an extent as a series wound motor. They are adapted to driving pumps, etc., where fairly steady speed and starting torque are required.

The single phase alternating-current motor has been quite well developed during the last few years, but it has as yet come into rather limited use. The polyphase motor has come into very general use, its relative simplicity being a strong feature. These induction motors may be either of two general types, the squirrel cage type and the slip ring, or wound motor type. The squirrel cage type is the more simple and has no moving contacts, and hence no wearing parts except the bearings. Relative freedom from sparking is assured and the motors can be used with some safety in locations surrounded by inflammable or explosive material. For constant speed service with fairly infrequent starting or with frequent startings on circuits where close voltage regulation is not essential the squirrel cage is the preferable type. The slip ring type, however, by the use of adjustable starting resistance in series with the secondary, will start a given load with less current, and is therefore preferable where frequent starting with heavy load is necessary and where close voltage regulation is essential. The slip ring motor is also useful for some kinds of varying speed service, notably hoists and cranes, where its service is comparable to that of a series wound d. c. motor.

Motors for variable speed use are designed for intermittent service of a maximum of 30 minutes duration and this reduces the cost. Motors when well protected have a long life. The brush is the quickest wearing part and one will last from 1 to 4 years, depending on the care given and the kind of service. When a motor is overloaded the brush sparks and, therefore,

wears out very rapidly. A brush will last longer on alternating current than on direct. The following prices will show in a measure the relative cost of variously wound motors:

TABLE 111

5	H. P. .... Alternating current	Squirrel cage	$108.00
5	H. P. .... Direct current	Shunt wound	145.00
5	H. P. .... Alternating current	Slip ring	195.00
5	H. P. .... Direct current	Series wound	170.00
7½	H. P. .... Alternating current	Squirrel cage	177.00
7½	H. P. .... Direct current	Shunt wound	190.00
7½	H. P. .... Alternating current	Slip ring	240.00
7½	H. P. .... Direct current	Series wound	210.00
10	H. P. .... Alternating current	Squirrel cage	202.00
10	H. P. .... Direct current	Shunt wound	215.00
10	H. P. .... Alternating current	Slip ring	260.00
10	H. P. .... Direct current	Series wound	230.00

TABLE 112—DIRECT CURRENT CONSTANT SPEED MOTORS FOR 115, 230 AND 500 VOLTS

Frame.	H. P.	115 Volts Speed.	115 Volts Price.	230 Volts Speed.	230 Volts Price.	500 Volts Speed.	500 Volts Price.	Appx. Wt. Gross.	Pulleys.
G-6	⅛	925	$ 27.00	....	......	....	......	90	2x1½
G-6	¼	1,850	27.00	1,850	$ 27.00	....	......	90	2x1½
AAF	⅜	935	37.00	....	......	....	......	145	3x 2½
AAF	½	1,250	36.00	1,250	37.00	....	......	145	3x 2½
BF	¾	375	73.00	....	......	....	......	400	5x 3½
AAF	¾	1,875	37.00	1,875	38.00	....	......	145	3x 2½
BF	1	500	71.00	500	73.00	....	......	400	5x 3½
AF	1	1,150	43.00	1,150	44.00	1,250	46.00	260	4x 3
AAF	1	2,500	37.00	2,500	38.00	....	......	145	3x 2½
BF	1½	750	67.00	750	68.00	....	......	400	5x 3½
AF	1½	1,750	43.00	1,750	44.00	1,925	46.00	260	4x 3
BF	2	1,000	69.00	1,000	70.00	1,100	74.00	400	5x 3½
AF	2	2,300	43.00	2,300	44.00	2,500	46.00	260	4x 3
EF	2½	275	158.00	....	......	....	......	780	8x 5½
CF	2½	650	90.00	650	93.00	....	......	595	6x 4
BF	3	1,500	69.00	1,500	70.00	1,650	74.00	400	5x 3½
CF	3½	910	88.00	910	90.00	1,000	93.00	595	6x 4
EF	3¾	410	156.00	410	158.00	....	......	780	8x 5½
QF	5	380	188.00	380	192.00	....	......	1,325	10x 7¾
DF	5	935	109.00	935	111.00	1,030	114.00	630	8x 5½
CF	5	1,300	89.00	1,300	92.00	1,450	94.00	595	6x 4
HF	7½	180	336.00	....	......	....	......	2,200	13x 8¾
FF	7½	375	232.00	375	236.00	....	......	1,535	10x 7¾
EF	7½	825	150.00	825	154.00	910	158.00	780	8x 5½
DF	7½	1,400	109.00	1,400	112.00	1,550	115.00	630	8x 5½
GF	10	335	302.00	355	306.00	....	......	1,710	13x 8¾
QF	10	770	184.00	770	188.00	840	192.00	1,325	10x 7¾
EF	10	1,100	152.00	1,100	156.00	1,210	160.00	780	8x 5½
GF	12½	450	296.00	450	300.00	....	......	1,710	13x 8¾
HF	15	375	344.00	375	356.00	....	......	2,200	13x 8¾
GF	15	525	300.00	525	305.00	....	......	1,710	13x 8¾
FF	15	750	232.00	750	236.00	825	246.00	1,535	10x 7¾
QF	15	1,150	186.00	1,150	190.00	1,260	195.00	1,325	10x 7¾
KF	20	255	528.00	255	528.00	....	......	4,450	20x14
IF	20	350	432.00	350	424.00	....	......	2,775	16x11

TABLE 112—DIRECT CURRENT CONSTANT SPEED MOTORS FOR 115, 230 AND 500 VOLTS—Continued

Frame.	H. P.	115 Volts Speed.	115 Volts Price.	230 Volts Speed	230 Volts Price.	500 Volts Speed.	500 Volts Price.	Appx. Wt. Gross.	Pulleys.
GF	20	715	306.00	715	306.00	780	318.00	1,710	13x 8¾
FF	29	960	236.00	960	240.00	1,050	248.00	1,535	10x 7¾
HF	25	625	344.00	625	340.00	685	352.00	2,200	13x 8¾
GF	25	900	308.00	900	312.00	990	310.00	1,710	13x 8¾
KF	30	375	530.00	375	530.00	....	......	4,450	20x14
LF	30	210	712.00	210	680.00	....	......	4,900	28x18½
HF	30	750	344.00	750	340.00	825	352.00	2,200	13x 8¾
GF	30	1,050	308.00	1,050	312.00	1,155	318.00	1,710	13x 8¾
IF	35	600	432.00	600	424.00	660	436.00	2,775	16x11
HF	35	850	348.00	850	344.00	935	356.00	2,200	13x 8¾
KF	40	515	536.00	515	530.00	570	540.00	4,450	20x14
IF	40	700	432.00	700	424.00	770	436.00	2,775	16x11
KF	45	575	540.00	575	540.00	635	540.00	4,450	20x14
LF	50	330	720.00	330	720.00	370	730.00	4,900	28x18½
KF	50	625	540.00	625	532.00	690	540.00	4,450	20x14
IF	50	875	432.00	875	432.00	965	440.00	2,775	16x11
KF	60	750	548.00	750	540.00	835	544.00	4,450	20x14
LF	60	425	720.00	425	720.00	470	724.00	4,900	28x18½
MF	75	370	960.00	370	952.00	405	952.00	6,100	28x20
LF	75	515	536.00	515	528.00	570	736.00	4,900	28x18½
MF	100	490	980.00	490	972.00	540	972.00	6,100	28x20
MF	125	610	1,000.00	610	980.00	670	900.00	6,100	28x20

Prices are for shunt wound open type motors, and include sliding base, standard pulley and Cutler Hammer, automatic release.

For compound wound motors add 3 per cent to net price.

For semi-closed motors with gridiron doors add 5 per cent to net price.

If sliding base or pulley are not wanted deduct 2 per cent from net price for base and 1 per cent from net price for pulley.

Frames G-6, AAF, AF, BF and CF are bi-polar machines; the remainder are multi-polar.

When operated at 110 or 220 volts, speeds will be approximately 4 per cent less.

Speeds may vary 5 per cent above or below those listed.

TABLE 113—SINGLE PHASE SELF-STARTING MOTORS FOR 110 OR 220 VOLTS, 60 CYCLES

½ H.P.	1,800 R.P.M.	$ 56.70	½ H.P.	1,200 R.P.M.	$ 68.40
¾ H.P.	1,800 R.P.M.	64.10	¾ H.P.	1,200 R.P.M.	72.60
1 H.P.	1,800 R.P.M.	68.45	1 H.P.	1,200 R.P.M.	71.90
1½ H.P.	1,800 R.P.M.	72.60	1½ H.P.	1,200 R.P.M.	87.20
2 H.P.	1,800 R.P.M.	77.00	2 H.P.	1,200 R.P.M.	102.50
2½ H.P.	1,800 R.P.M.	85.05	3 H.P.	1,200 R.P.M.	119.50
3 H.P.	1,800 R.P.M.	94.05	4 H.P.	1,200 R.P.M.	162.20
3½ H.P.	1,800 R.P.M.	98.30	5 H.P.	1,200 R.P.M.	177.70
4 H.P.	1,800 R.P.M.	106.90	7½ H.P.	1,200 R.P.M.	200.00
5 H.P.	1,800 R.P.M.	115.20	10 H.P.	1,200 R.P.M.	256.00
7½ H.P.	1,800 R.P.M.	177.50			
10 H.P.	1,800 R.P.M.	200.00			
15 H.P.	1,800 R.P.M.	256.00			

Starting boxes are furnished with 7½, 10 and 15 H. P. motors only.

Prices include sub-base and belt tightener attachment.

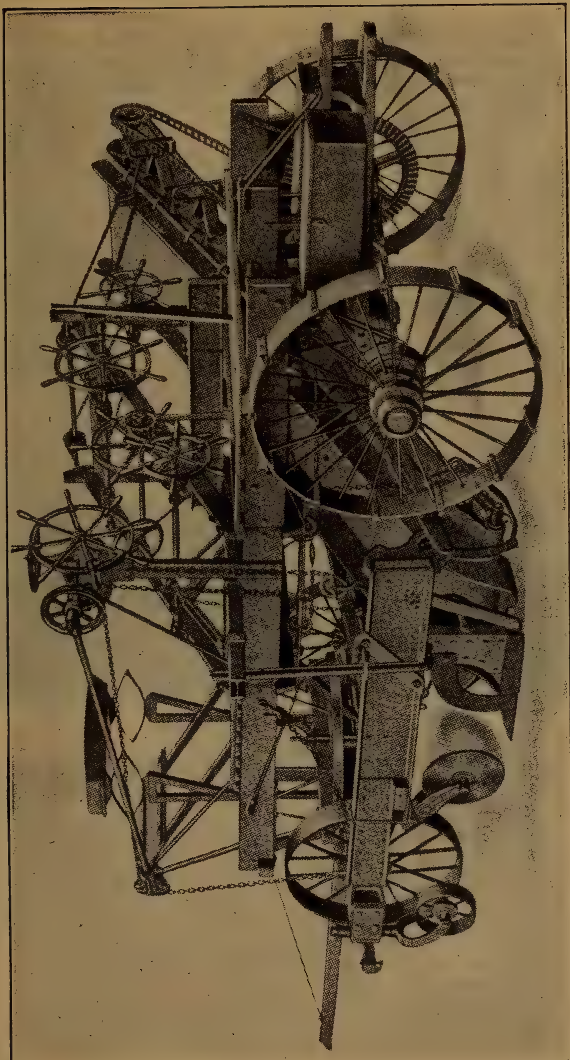

Fig. 96. Elevating Grader and Wagon Loader.

ELEVATING GRADERS

These machines are generally drawn by twelve horses (eight in front and four hitched to a push cart behind) or more, or by a traction engine. The machine consists primarily of a plow which casts a furrow on a transversely moving belt that elevates the earth, and dumps it into wagons or at one side. See Figs. 96 and 97. An elevating grader of the best type with a combined wood and steel frame weighing 10,000 lbs., sells for $1,050 f. o. b. Indiana. The advantage of the combined wood and steel frame lies in the fact that, a machine of this type being subject to great strains, if a steel channel, angle, or tee is badly bent it is generally necessary to send to the factory for a new part; if a wooden beam is broken a new one can be made and fitted on the job. This machine will excavate and dump on the bank 1,000 yards per ten-hour day, or load 500 to 600 yards in wagons, wherever stone or roots are not of sufficient size to impede progress in plowing, and where the ground is free from frost, and is

Fig. 97. Reversible Grader.

firm enough to support the machine and the teams. A 16 H. P. traction engine or 14 horses are necessary to operate one of the typical machines of this class.

An all steel elevating grader of the reversible type with a 32-foot elevator complete, which the manufacturers claim will load one ½ cubic yard wagon a minute or 900 cubic yards per day, costs $2,000. The elevating belt is propelled by a 7 H. P. steam or gasoline engine on top of the machine, total weight with gas engine 14,000 lbs., with steam engine 17,000 lbs. A heavy traction engine for pulling and for supplying steam for the belt engine is necessary.

The following is the cost of stripping a gravel pit, covered with sandy loam, with a number of pockets of varying depths up to 10″. The contract called for the stripping of a space 3,000 feet long and 250 feet wide, and the placing of the material in storage piles in the rear.

The outfit consisted of 1 elevating grader, 6 1¼ yard dump wagons, 4 No. 2 wheelers, and 2 plows. Wheelers were used to excavate the pockets. More wagons should have been provided as the grader was delayed waiting for them.

19,970 cubic yards were stripped during the month of September, 1909.

Grader—	
2½ Teams on push, 24 days, @ $5.00	$ 300.00
8 Teams on machine, 24 days, @ $5.00	960.00
Wagons—	
5½ Teams, 24 days, @ $5.00	660.00
Wheelers—	
3 Teams on wheelers, 11 days, @$5.00	165.00
1 Team on plow, 11 days, @$5.00	55.00
1 Team on scraper, 11 days, @ $5.00	55.00
Labor—	
1 Foreman	85.00
1 Mucker, 24 days, @ $2.00	48.00
1 Corral man, 28 days, @ $2.00	56.00
2 Grader drivers, 24 days, @ $2.25	108.00
Total cost at 12½ cents per yard	$2,492.00

Mr. Daniel J. Hauer gives the cost per cu. yd. of earth excavation with elevating graders on several railroad jobs. The following rates of wages were paid for a 10 hour day:

Foreman	$ 2.50
Operators on grader	1.50
Laborers and team men	1.50
Engineer	2.75
Water boy	.75
Superintendent	3.00
Timekeeper	2.50
12 Horse teams and 2 drivers	22.60
2 Horse teams and 1 driver	4.60
3 Horse teams and 1 driver	6.25

	Ex. I.	Ex. II.	Ex. III.	Ex. IV.	Ex. V.	Ex. VI.	Ex. VII.	Average.
Loading	$0.130	$0.067	$0.085	$0.108	$0.061	$0.098	$0.153	$0.100
Hauling	.111	.078	.117	.149	.077	.094	.260	.127
Dumping	.041	.011	.019	.019	.018	.049	.050	.029
Water boy	.001	.002	.002	.003	.002	.003	.002	.002
Foreman	.012	.007	.015	.010	.006	.009	.015	.010
Total	$0.295	$0.165	$0.238	$0.289	$0.164	$0.253	$0.480	$0.268
Lead, ft.	400	1,000	600	700	500	500	1,700	800
Cu. yds. per day	206	380	300	284	417	260	167	288

Mr. Gillette places the average output of elevating graders loading into dump wagons at 500 cu. yds. per day, and estimates the interest and depreciation as 20 per cent of the first cost distributed over 60 working days per year. The author has found that the life of a grader is from 5 years to as much as 12 years when the grader is well cared for.

ENGINES

We illustrate two types of portable engines, Figs. No. 98 and 99.

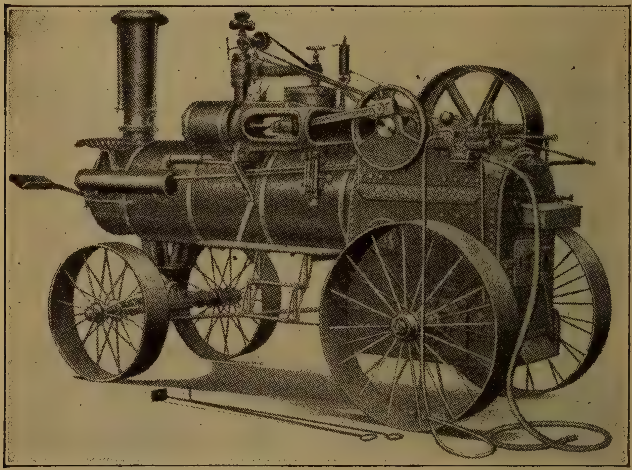

Fig. 98. 10x10-inch Cylinder Simple Portable Engine.

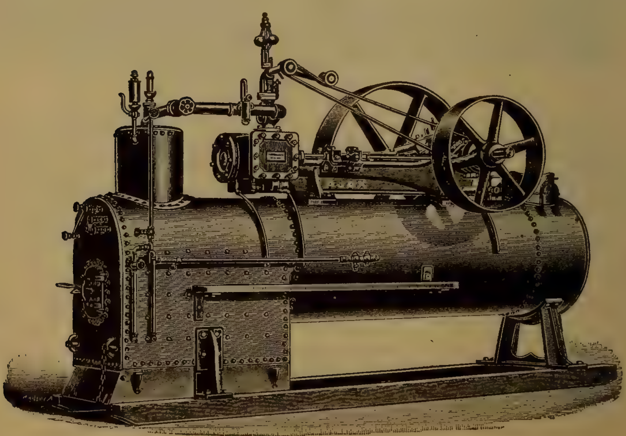

Fig. 99. Ajax Center Crank Engine on Skids.

TABLE 114—STEAM ENGINES—I

Prices and sizes of simple center crank engines, without boilers, are:

Price.	H. P.	Bore.	Stroke.	R. P. M.	Weight.
$116	4	4½	6	225	750 lbs.
127	5	5	6	215	325 lbs.
142	6	5½	8	200	1,270 lbs.
153	8	6¼	8	200	1,300 lbs.
173	10	7	10	190	1,950 lbs.
184	12	7¾	10	180	2,025 lbs.
211	15	8½	11	175	2,375 lbs.
229	18	9	11	170	2,450 lbs.
280	20	9¼	12	150	3,230 lbs.
293	25	10	12	150	3,600 lbs.
369	30	10	15	130	4,300 lbs.
403	35	11	15	130	4,950 lbs.
451	40	12	15	125	5,350 lbs.

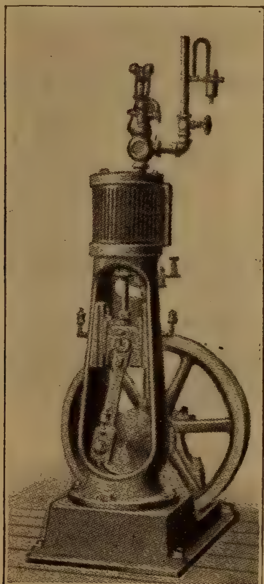

Fig. 100.

The prices of the same engines mounted on locomotive boilers, which, in turn, are mounted either on wheels or sills, are as follows:

II

On Wheels: Price.	H. P.	Weight, lbs.	On Sills: Price.	H. P.	Weight, lbs.	Cylinder: Bore.	Stroke.	Regular speed.	Length on wheels.	Length on sills.
$ 340	4	3,700	$ 304	4	2,580	4½	6	225	8	12
370	5	4,050	322	5	3,030	5	6	215	8	12
425	6	4,400	362	6	3,380	5½	8	205	28	14
450	8	4,900	389	8	3,700	6¼	8	205	8	14
500	10	6,050	430	10	4,740	7	10	180	9	14
565	12	7,350	486	12	5,950	7¾	10	180	9	16
635	15	8,400	550	15	6,950	8½	11	175	10	18
670	18	9,000	585	18	7,500	9	11	170	10	20
770	20	10,800	683	20	9,100	9¼	12	150	16	20
840	25	11,900	729	25	10,200	10	12	150	18	20
1,020	30	13,600	880	30	11,800	10	15	130	18	22
1,990	35	14,100	946	35	12,300	11	15	130	18	22
1,240	40	14,800	1,081	40	12,900	12	15	125	24	24
1,580	50	16,400	1,393	50	14,400	13	16	120	30	30

Prices include all fittings.

III—COMPOUND PORTABLE ENGINES

Length of Bore and Stroke (Inches).	Rated H. P.	Steam Pressure.	Price.
5¾x 8½x10	9	130 lbs.	$ 750
6⅛x 9 x10	12	130 lbs.	845
7 x10 x10	15	130 lbs.	940
7¾x11 x10	20	130 lbs.	1,035
9¼x13 x11	25	130 lbs.	1,130

For straw-burning attachment, including jacket on boiler, add $47.00 to prices above.

PORTABLE ENGINE EXTRAS.

Brake for portable engine, net............................$ 9.50
Driver's seat and footboard for portable engine, net, cash.. 2.75
Portable engine tongue with doubletrees and neckyoke, net, cash 11.25

IV—SIDE OR DISC-CRANK VERTICAL SELF-CONTAINED STEAM ENGINES.

SPECIFICATIONS AND PRICES.

Size, number	18	19	20	21	22	23	24
Horse-power, as usually rated	1½	3	5	7	10	14	20
Size of cylinder, inches	3x3	4x4	5x5	6x6	7x7	8x8	9x9
Revolutions per minute	300	250	250	200	190	180	160
Diameter of flywheel, inches	12	16	20	24	32	36	42
Face of flywheel, inches	3	4	5	6	7	8	9
Floor space occupied, inches	12x23	15x28	18x36	22x40	25x46	28x50	30x56
Weight of engine, pounds	225	425	600	1,000	1,400	2,050	2,650
Price of bare engine	$37.60	$61.00	$79.00	$ 98.00	$137.50	$182.00	$203.00
Price of oil cups (4)	1.37	1.37	1.48	1.48	1.67	1.67	1.67
Price of sight-feed lubricator	1.85	1.85	2.00	2.17	2.60	2.60	3.15
Price of throttle valve and nipples	.71	.84	.84	1.03	1.20	1.30	1.95
Price of governor	7.98	9.12	9.12	10.25	12.00	14.25	17.10
Price of governor belt	.40	.45	.51	.57	.74	.94	1.14
Price of engine, complete	49.60	74.10	93.00	115.00	155.00	205.00	228.00

The stationary steam engine shown in Figure 101 is of the box-bed type, made very heavy; balanced fly-wheel and pulley, D slide valve; complete with all fittings except steam connections, exhaust pipe, and governor belt.

V

Horse-power	15	25	40	55	60
No. of revolutions....	175	150	130	125	125
Cylinders, diameter and stroke, inches.....	8¼x10	10x12	12¼x15	14x18	14x20
Diam. of flywheel, ins..	66	81	96	107	108
Leng. of bed plate, ins.	1,000	1,500	2,000	2,500	3,500
Width of bed plate, ins.	80	87	100	122	134
Diam. of pulley, ins...	34	48	54	60	60
Face of pulley, ins.....	9	12	14	16	16
Weight, complete, lbs.	2,700	4,700	7,000	9,000	10,000
Price	$312.00	$338.00	$505.00	$670.00	$716.00

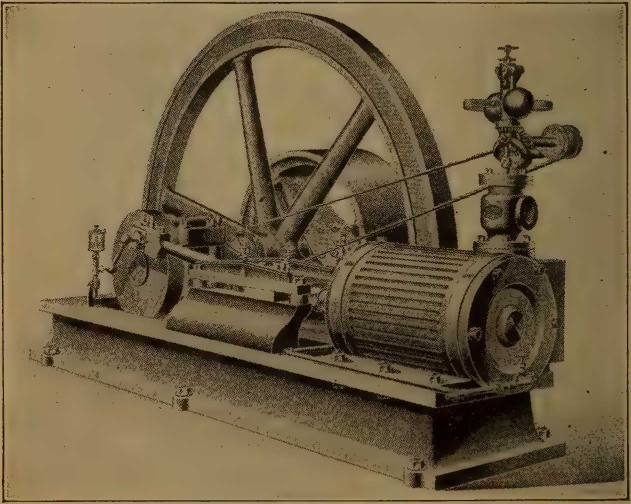

Fig. 101. Stationary Engine.

ESTIMATING THE HORSE POWER OF CONTRACTORS' ENGINES.

The size of an engine is usually expressed in terms of the diameter of the cylinder bore by the length of the piston stroke. In a 6x8 engine, the cylinder has a bore of 6″ and the piston has a stroke of 8″. This stroke is, of course, just twice the length of the "throw" of the crank arm. Bear in mind, therefore, that

the "size of cylinder" as given in catalogue is the bore of the cylinder by the stroke of the piston, and not by the full length of the cylinder.

If a contractor's engine is designed to have a piston speed of 300 ft. per minute, and is using steam with a boiler pressure of 100 lbs., it is an easy matter to deduce a very simple rule for estimating the horse-power of the engine. The following rule is precisely correct when the product of the piston speed by the mechanical efficiency is equal to 1050; and this is ordinarily the case with contractors' engines having cylinders of 8″ or more in diameter.

RULE: To ascertain the horsepower, square the bore of the cylinder and divide by four.

Thus, if the engine is 8x8, we have a cylinder bore of 8. Hence, squaring 8 we have 64, and dividing by 4 we get 16, which is the horsepower. This is the actual delivered, or brake, horsepower. For small engines, whose piston speeds are usually less, it is safe to divide the square of the bore by five instead of by four. A 6x6 engine would, therefore, have 7 horsepower.

If the engine has two cylinders (duplex) of course the horsepower is twice that of a single cylinder.

Gasoline Engines are usually furnished with the machinery they are designed to operate, and for that reason when machinery which may be operated by gasoline is described, the price of the engine is included in the total cost. However, at times, it may be desirable to equip a piece of machinery now driven by steam or other power, with a gasoline engine.

The price of 4-cycle marine engines of the very best type is as follows:

TABLE 115

H. P.	No. Cylinders.	No. Rev. per Min.	Weight, Lbs.	Price.
12	2	500	240	$ 450
18	3	500	800	600
24	4	500	980	925
40	6	550	1,350	1,425
20	2	450	1,050	825
30	3	450	1,400	1,275
40	4	450	1,850	1.375
60	6	500	2,600	2,200
50	6	700	1,000	1,875
80	6	650	1,900	2,450

This price includes all equipment.

A gas, gasoline, distillate or alcohol driven engine, of horizontal, water-cooled type, Fig. 102, has in a single casting combined a cylinder and cylinder head, which does away with joints in the water jacket. Both induction and exhaust valves are me-

chanically operated and separately caged. The igniter is of the make and break type and is attached to the end of the cylinder as a single plug. The governor is of the flyball type running in ball bearings. Each engine has two fly wheels with split hubs, lugs on the arms provide for attaching pulley to either side. When equipped for gas it is provided with an improved type of cock which is graduated to obtain and instantly regulate the mixture. When equipped for gasoline, distillate or alcohol, a pump delivers the liquid fuel to the vaporizer. The ratings, dimensions and prices are as follows:

H. P.	4	6	8	15	20	25	30
Rev. per m.	350	325	275	250	220	200	190
Pulley ...	12x6	15x6	18x6	24x8	26x8	28x8	28x10
Approx. fl. space ...	24x36	28x56	32x66	38x83	44x95	48x108	50x120
Price	$185.00	$260.00	$320.00	$525.00	$675.00	$750.00	$850.00

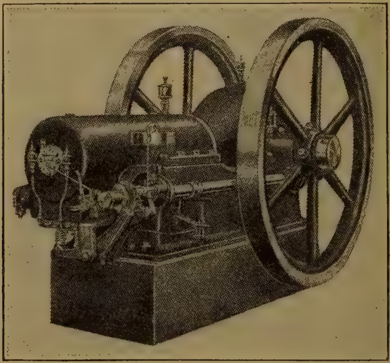

Fig. 102.

The engines are furnished with the following equipment: Oil cups, wrenches, exhaust pot or muffler, can of cylinder oil, batteries and gas regulator. Twenty gallon gasoline storage tank, cooling tanks, magnetos or dynamos, friction clutch pulleys and other accessories are not considered a regular part of the equipment as requirements in each installation are apt to be special.

A magneto costs $10.00. A clutch costs $20.00.

A small but powerful gasoline engine, known as the Farm Pump Engine, may be attached in a few minutes, and used to operate small pumps, saw rigs, grind-stones, etc. This engine is of the vertical type, air-cooled; its weight with battery box, ignition coil, and batteries, is 280 lbs., crated, 330 lbs. It con-

sumes about 2 qts. of gasoline in 10 hours. The price f. o. b. cars, factory, is $70.00. (See Figs. 103 and 104.)

This engine, mounted on a wooden base, with a side-suction diaphragm pump costs as follows: 3 in. pump, without hose,

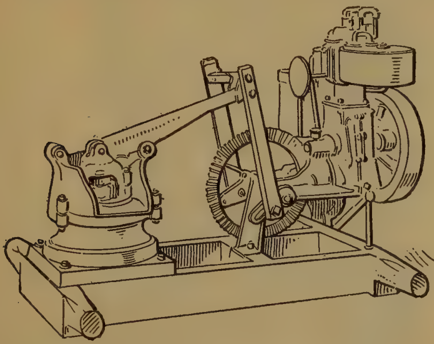

Fig. 103. The Diaphragm Pump.

$110.00, capacity, 2400 gals. per hour; 4 in. pump, without hose, $130.00, capacity 3800 gals. per hour. With a bottom suction diaphragm pump, without pipe, this engine costs as follows:

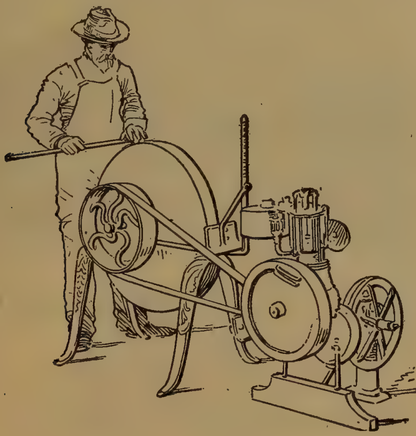

Fig. 104. The Grindstone.

3 in. pump, $108.00; 4 in. pump, $125.00. The engine without pump or hose, but with frame and all connections, costs $90.00.

The same machine equipped with a double acting force pump costs: 5 in. pump, $105.00; 3 in. pump, $100.00; engine with frame and attachments, $85.00.

The same outfit with a tank pump, costs $105.00.

The shipping weight of any of the above outfits is about 500 lbs.

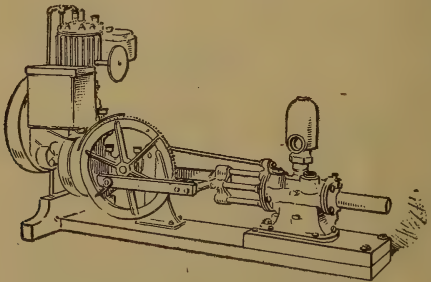

Fig. 105. The Pressure System.

A very simple gasoline engine is shown in Figure 106. It is of the open-jacket water cooling system, gas-tank in iron base, governor of the inertia type, make and break ignition, and the equipment includes muffler, coil, wrenches, oil can, etc.

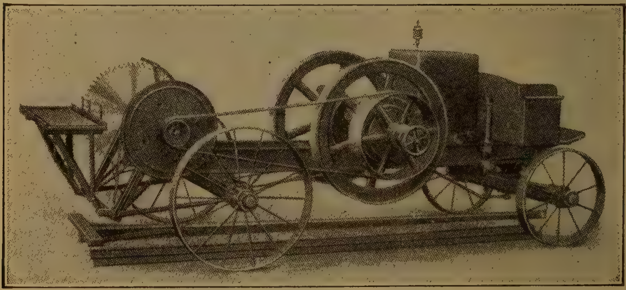

Fig. 106. 8 and 12 H. P. "Bull Dog" Sawing Outfit, Complete with Friction Clutch and Saw Blade.

H. P.	Speed.	Weight.	Pulley.	Price.
1½	400	275	6x4 ins.	$ 70.00
2½	400	475	8x4 ins.	110.00
5	375	800	12x6 ins.	200.00
6	375	1,050	14x6 ins.	215.00
8	375	1,800	18x6 ins.	295.00
12	360	2,100	20x6 ins.	425.00

The price of the above engines, mounted on a truck, is $56.00 extra. Engines up to 6 H. P. are mounted on a hand truck, and the 8 and 12 H. P. on a steel truck.

The price of these engines, mounted on a steel truck, with saw attachment on the rear, is as follows:

H. P.	Weight. (Lbs.)	Price.	H. P.	Weight. (Lbs.)	Price.	H. P.	Weight. (Lbs.)	Price.
1½	500	$195.00	2½	1,250	$235.00	5	1,600	$340.00
6	1,850	365.00	8	2,700	450.00	12	3,400	575.00

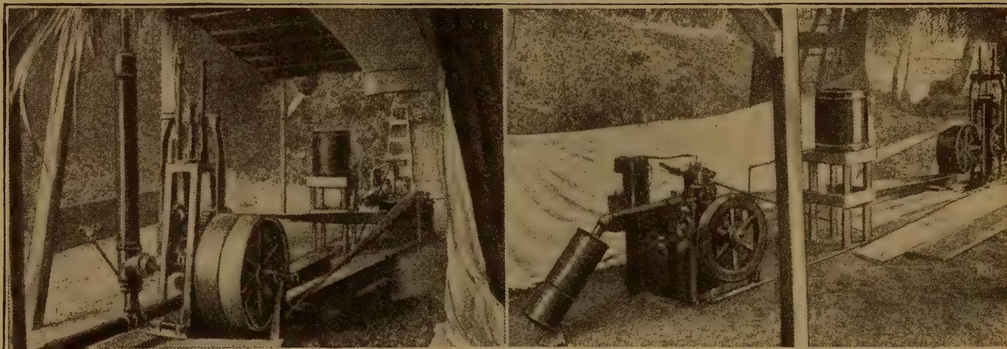

Fig. 107. Irrigation Plant Owned by H. H. Beckwith, Glendora, California.

Vertical gasoline-driven, water-cooled engines of a certain make are furnished in the following models and outfits:

Model T—Outfit A.—Equipped with automatic throttling governor, iron foundation base, and driving pulley. Governor is of the vertical flyball type which may be set to operate at any desired speed by means of a thumb nut. This engine is suitable for driving saw-rigs, small machinery, and in small machine shops, electric lighting, etc.

Model T—Outfit B.—Same as outfit A, except that the base is extra, and the driving pulley is different. Suitable when mounted on skids or trucks for portable rigs, harvesters, binders, mixers, well-drills, etc. Model T—Outfit C.—Same as B but without the governor. Suitable for steady pumping, etc.

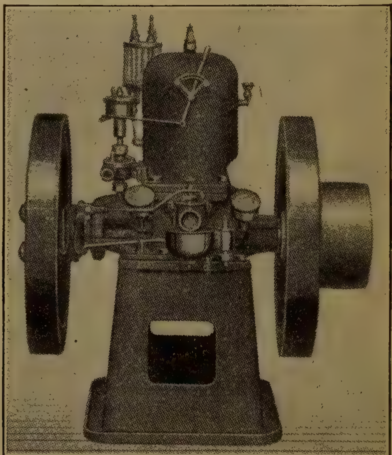

Fig. 108. Model "R"—Outfit "D."

Model R—Outfit D.—Equipped with iron base, extra fly wheel, with driving pulley, and automatic ball governor. Suitable for small machinery.

Model R—Outfit E.—Same as outfit D, but without the base and the extra fly wheel with driving pulley, for which a cup pulley is substituted. Suitable for portable work in driving small pumps, saw-rigs, etc.

Model R—Outfit F.—Same as outfit E, but without governor. Suitable for pumping, driving railway velocipedes, hand cars, etc.

Extra fly wheel for Model T outfit costs $10.00. Foundation bases for T-B or T-C engines, $16.00; for R-E and R-F outfits, $10.00. Extra pulleys for R-D or R-E engines, $3.00. Magneto for T-A and R-D engines, $16.00. Portable hand trucks for these engines, fitted for 7 in. iron wheels, cost: 4 to 6 H. P., $12.00; 8 to 12 H. P., $16.00.

TABLE 116

Price List.

H. P.	Price.	Model.	Standard Pulleys. Diam.		Face.	Weight.
			——Inches——			
12 Outfit A	$219.00	T-A	10	x	10	600
12 Outfit B	196.00	T-B	10	x	6	482
12 Outfit C	176.00	T-C	10	x	6	460
8 Outfit A	186.00	T-A	10	x	10	540
8 Outfit B	168.00	T-B	10	x	6	437
8 Outfit C	152.00	T-C	10	x	6	420
6 Outfit D	124.00	R-D	8	x	4	368
6 Outfit E	110.00	R-E	8	x	4	245
6 Outfit F	84.00	R-F	8	x	4	228
4 Outfit D	104.00	R-D	8	x	4	334
4 Outfit E	90.00	R-E	8	x	4	215
4 Outfit F	76.00	R-F	8	x	4	195
3 Outfit F	65.00	R-F	6	x	4	140

The equipment furnished includes spark coil, dry cells, switch, muffler and 5 gallon gasoline tank.

Extra fly wheel for Model T outfit costs $10.00. Foundation bases for T-B or T-C engines $16.00; for R-E and R-F outfits,

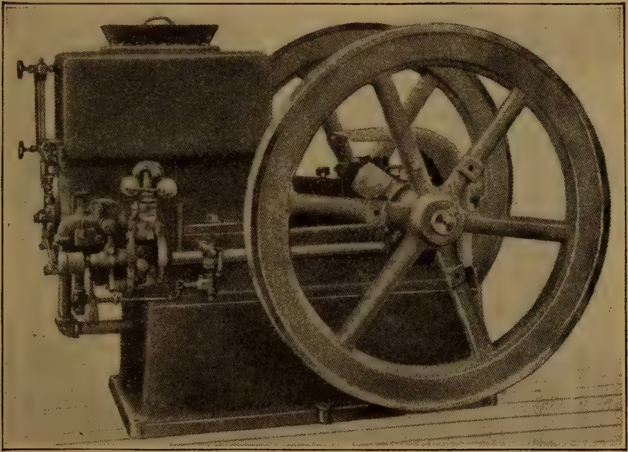

Fig. 109.

$10.00. Extra pulleys for R-D or R-E engines, $3.00. Magneto for T-A and R-D engines, $16.00. Portable hand trucks for these engines, fitted with 7 in. iron wheels cost: 4 to 6 H. P., $12.00; 8 to 12 H. P., $16.00.

Horizontal gasoline driven engines (see Fig. 109), having the open water jacket cooling system, are regularly fitted with the following equipment: Standard pulley, oil and grease cups, wrenches and pliers, muffler, batteries, coil, oil cans, etc. The cost of the engine mounted is as shown on following page.

TABLE 117

Rated H. P.	Revolutions per Min.	Size of Standard Pulley Diam. Face	Approximate Floor Space	Shipping Weight	Price
3	400	10x 5	28x42	900	$115.00
5	375	14x 6	34x51	1,500	182.00
7	350	16x 8	38x55	1,900	245.00
9	320	18x 8	44x70	2,500	305.00
12	300	20x12	43x71	3,600	400.00
15	280	24x14	48x82	4,700	470.00
18	280	28x14	48x82	4,800	525.00

HOISTING ENGINES

Steam driven engines are manufactured in an immense variety of styles. Below are given the average prices of the types most generally used. These prices and weights vary greatly, but they

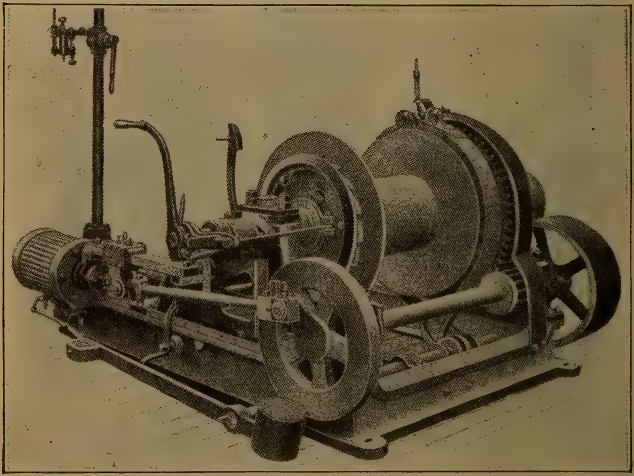

Fig. 110. Single Cylinder, Single Friction Drum, Hoisting Engine.

are accurate enough to be used for estimating. For the purpose of tabulating, hoisting engines have been arbitrarily divided into the following classes (See Table 118):

SINGLE CYLINDER ENGINES

Class. 1. Reversible link motion, single friction drum, elevator sheaves. Adapted to coal yards, docks, stevedores, ships, centrifugal pumps, pile driving, etc.

Class. 2. Single friction drum. Adapted for same uses as Class 1 engine.

Class 3. Double friction drum. Suitable for general hoisting purposes, moving pumps, for docks, coal yards, pile driving, etc.

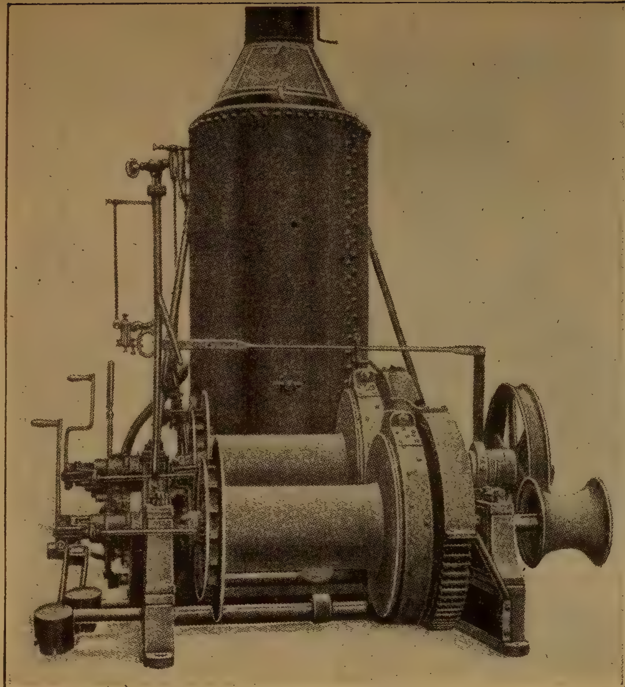

Fig. 112. Double Cylinder, Double Friction Drum, Link Engine.

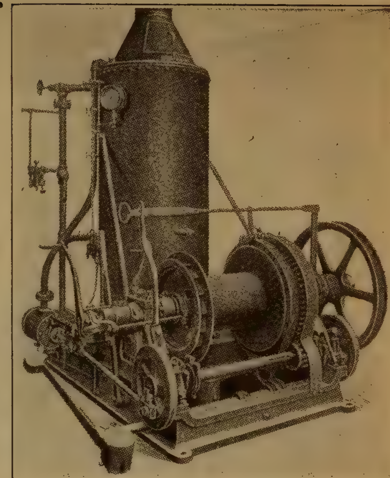

Fig. 111. Double Cylinder, Friction Drum, Link Motion Engine.

DOUBLE CYLINDER ENGINES

Class 4. Link motion, single friction drum, elevator sheave. Adapted to general contracting use, and especially for operating material elevators, and, in larger sizes, for use on barges, docks, etc.

Class 5. Single friction drum, suited to general hoisting, erecting, log skidding, etc.

Class 6. Double friction drum, link motion engine especially adapted to small cableways, sewer and general contractors' work.

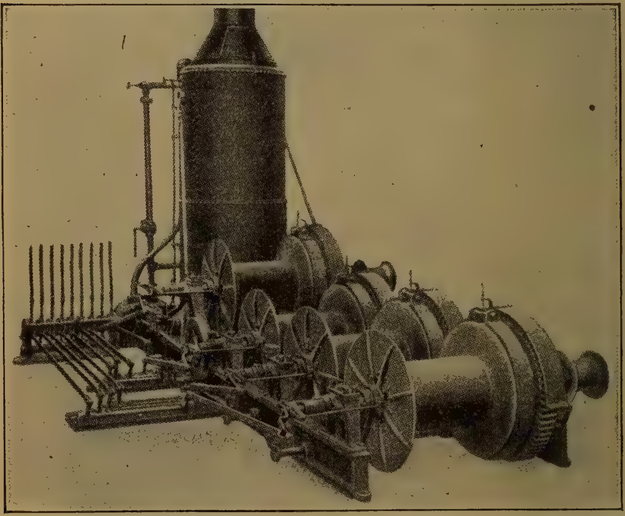

Fig. 113. Double Cylinder, Four Friction Drum, Link Motion Engine.

Class 7. Double friction drum engine. Adapted to hauling cars, pile driving, bridge building,. operating derricks, and general hoisting purposes, circular saws, concrete mixers, centrifugal pumps, etc.

Class 8. Double friction drum, with boom swinger attached for derricks.

Class 9. Independent swinging engines for derricks. Double winch, non-reversible.

Class 10. 3 friction drum, with reversing gears and drums, for boom derricks with clam-shell or orange-peel buckets.

Class 11. 4 friction drum, link motion engine, especially adapted to logging, quarrying, etc.

TABLE 118

Class	H.P.	Diam.	Stroke	Wt. Hoisted on Single Line (Lbs.)	Without Boiler Weight	Without Boiler Price	With Boiler Weight	With Boiler Price	Mounted on Truck with Boiler Weight lbs.	Mounted on Truck with Boiler Price
1	4	4½	5¾	800	1,800	$ 215.00	3,000	$ 350.00		
	8	5	8	1,200	2,500	300.00	5,500	550.00		
	12	6¼	8	1,500			7,200	573.00		
	20	7	10	2,000			9,000	720.00		
2	4	5	8	1,000	2,200	315.00	4,600	456.00		
	8	6¼	10	1,700	3,400	330.00	6,900	582.00		
	15	8¼	10	3,500	4,800	438.00	8,400	774.00		
	25	10	12	7,500			14,500	1,026.00		
3	4	5	8	1,000	2,200	395.00	5,800	534.00		
	8	6¼	10	1,700	3,400	530.00	8,500	560.00		
	15	8¼	10	3,500	4,800	662.00	10,500	882.00		
	25	10	12	7,500			18,000	1,176.00		
4	6	5	6	1,500			5,400	550.00		
	8	5	8	2,000	3,000	450.00	5,900	600.00	6,500	$ 650.00
	12	6¼	8	3,300	3,900	550.00	7,500	725.00		
	16	6¼	10	3,800	4,200	660.00				
	30	8¼	10	6,000	6,600	780.00				
	50	10	12	9,500	10,900	940.00				
5	8	6¼	8	2,000	2,700	340.00	6,300	600.00	6,300	610.00
	16	6¼	10	4,000	3,700	420.00	7,500	725.00	8,900	780.00
	20	7	10	5,000	4,900	465.00	8,700	800.00	10,500	860.00
	30	8¼	10	7,500	6,400	550.00	11,500	950.00	11,700	1,100.00
	50	10	12	11,000	10,500	740.00	18,500	1,340.00		
6	8	5x	8	1,800	4,500	470.00	7,000	720.00		
	12	6¼	8	2,800	5,400	600.00	8,000	800.00		
	16	6¼	10	4,000	6,050	615.00	8,600	835.00		
	20	7	10	4,800	6,950	668.00	10,700	910.00		
	30	8¼	10		8,900	834.00	14,500	1,200.00		
	50	10	12		14,500	1,100.00	26,000	1,650.00		
7	8	5	8	1,800	4,000	420.00	7,250	630.00	8,000	700.00
	16	6¼	10	4,000	5,500	530.00	9,440	810.00	11,100	885.00
	20	7	10	5,000	6,700	575.00	11,000	880.00	12,400	975.00
	40	8½	12	9,500	11,100	790.00	17,500	1,150.00		
	50	10x	12	12,500	13,500	925.00	21,000	1,460.00		
8	8	5x	8	2,000	5,600	600.00	8,700	798.00		
	16	6¼	10	4,000	9,000	735.00	12,500	966.00		
	30	8¼	10	4,800	12,600	915.00	15,900	1,266.00		
	50	10	12	12,500	17,500	1,206.00	29,500	1,770.00		
9	8	5	8	1,900	2,250	450.00				
	16	6¼	10	4,000	3,600	550.00				
	30	8¼	10	9,000	5,700	735.00				
	50	10	12	15,000	9,500	980.00				
10	20	7	10	5,000			16,800	1,290.00		
	40	8½	12	9,000			24,500	1,800.00		
11	20	7	10	4,800			15,500	1,300.00		
	50	10	12	11,000			31,000	2,090.00		

The prices of electrically operated hoist engines, including motors, vary with the current, voltage, etc., but for estimating purposes it is generally true that motor driven hoisting engines cost more than steam driven engines complete with boilers.

A hoist engine used 10 years on pile driving with minor repairs was then used three years. The original cost was $750.00. The average cost of repairs after 10 years' use was $10.00 per working month.

The cost in labor of unloading from cars and setting up a hoisting engine ready for work averages from $35 to $50.

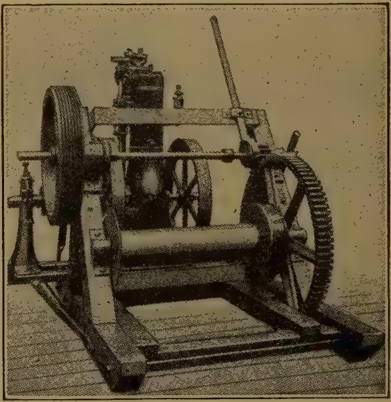

Fig. 114. Gasoline "V" Friction Hoist.

Several types of hoisting engines are illustrated in Figs. Nos. 110 to 115.

GASOLINE HOIST

A single drum 2½ H. P. gasoline hoisting engine, having a capacity of 1000 lbs. on a single line.

Engine, 2½ H. P., gasoline, electric ignition, complete with batteries, coil, muffler, etc.

Drum, 5½ ins. diameter, 25½ ins. between flanges, "V" friction, 24 in. diameter, rope speed 25 ft. per minute.

Floor-space, 4 ft. 8 in. x 4 ft. 5 in. Price, equipped with foot brakes, friction clutch, and shifting lever, $280.00.

SMALL BELT DRIVEN HOIST

A reversible friction hoist designed to be operated by a gasoline engine or motor through a belt has the following specifications:

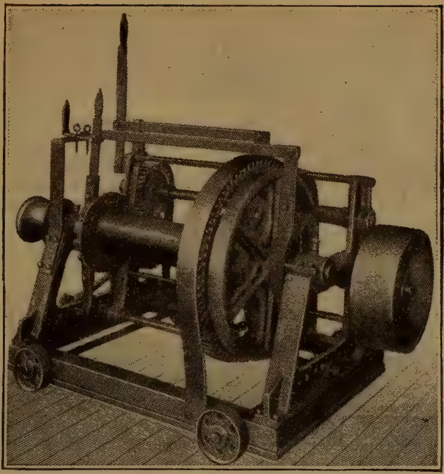

Fig. 115. Reversible Hoist.

DIMENSIONS AND CAPACITY

Weight, 1,200 lbs.
Floor space, 3 ft. 8 in.x2 ft. 8 in.
Drum: Diameter, 6 in.; between flanges, 19 ins.
Capacity of drum, 2,000 lbs. on a single line.
Elevator sheave, 24 ins. diameter; capacity, 400 lbs. lift.
Hoisting speed, 150 ft. per minute.
H. P. required, 5.
Complete with winch head, drum, elevator, and pulley, but not belt nor engine, $220.00.

EXCAVATORS

LAND DREDGE OR GRAB BUCKET EXCAVATOR

In building irrigation ditches in the Modisto and Turlock districts along the San Joaquin river in California in sand and hardpan a land dredge or grab bucket excavator was used for part of the work. The machinery is mounted on a skid platform 18x30 feet which rests on movable wooden rollers running on planks on the ground. The dredge moves along the axial line of the canal receding from the breast as it is excavated. It is moved ahead from 3 to 5 feet at a time by means of a steel cable anchored to a "dead man" and wound on a drum driven by the engine. The A-frame which supports the boom is 20 feet high. This boom inclines about 45° and may be swung 180° horizontally by a bull-wheel but has no vertical motion. The bucket is of the clam shell type, one cubic yard capacity, weighing 2800 lbs. The operator stands on a platform on the A-frame and controls the machine by 3 levers and 2 foot brakes. A 25 H. P. single cylinder gasoline engine furnishes the power and

Fig. 116. Clamshell Dredge Cleaning Canals in Imperial Valley.

drives a series of combination gear and friction brake drums controlling the motion of the excavating bucket. The machine cost $5,000. Wages of the crew of 5 men and a team during one month amounted to $305.00. The supplies, which included 400 feet of ⅜-inch hoisting cable costing $50.40, rollers costing $21.00, a large intermediate gear costing $14.00, depreciation of machine $40.00, and gasoline, oil, explosives, etc., amounting to $216.24. Fourteen thousand cubic yards were excavated at a cost of $0.035 per cubic yard.

Traction driven machines (Fig. 116), equipped with 15 cu. ft. clam shell buckets, were used by the California Development

Co. for cleaning canals too small to float dredges. These machines have a 40 ft. steel boom carried on an all steel frame. The maximum width of cut is 14 ft. The power is supplied by a 15 H. P. Gasoline engine. The machine has two forward traction speeds and one reverse. These machines cost $5,000 each, and the cost of handling material with them was about 13 cents per cu. yd.

The Bridge Conveyor Excavator illustrated in Fig. 117 was used on Contract 6 of the New York State Barge Canal. It is an adaptation to earth and rock excavation of a type of conveyor-

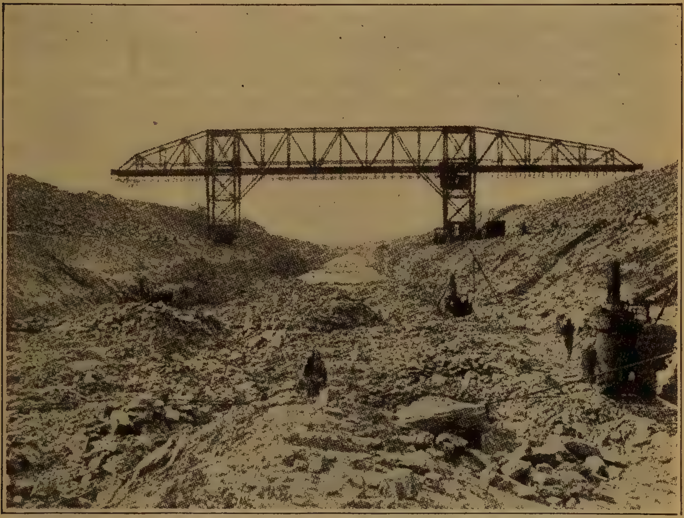

Fig. 117. Bridge Conveyor Excavator on Section 6, New York State Barge Canal.

excavator long employed at Great Lake ports for unloading ore vessels. The machine has proved fairly economical, and cost $105,000.

The machine consisted of two towers, each 90 ft. high, resting on a steel framework supported on 32 car wheels. The towers carried a two-truss bridge having cantilever arms extending over the spoil banks on each side. One tower was rigidly attached to its car frame, while the other had two sets of bearings, one of which permitted a variation of the distance between the cars, and the other allowed the tower to swing on an arc of 17° at right angles to the bridge axis.

All the machinery was operated by electric power obtained from the Rochester Railway & Light Co.

The bucket was of the clam shell type, weighed 9 tons, and had a nominal capacity of 8 cu. yds. The average load was, however, about 3 cu. yds. After the rock had been blasted, it was excavated and conveyed to the banks by the bucket. The total wages per 8-hour day were as follows:

1 Operator at $6.00	$ 6.00	
1 Electrician at $4.00	4.00	
1 Oiler at $3.25	3.25	
2 to 5 Laborers at $1.50 and $1.60	$3.00 to 8.00	
1 Team at $4.00	4.00	
1 Watchman at $2.00	2.00	
Bookeeper, part time at	125.00	per month
Timekeeper, part time at	80.00	per month
Superintendent, part time at	250.00	per month

During the 24 months of 1908 and 1909 the total output was 510,406 cu. yds. of rock and 39,721 cu. yds. of earth. During this period the machine was laid up an aggregate of 2 months on account of fire and for repairs to the bucket. The cost was as follows:

	Total Cost	Per Cu. Yd.
Repairs	$22,332.77	$0.0400
Electric power	26,630.00	0.0484
Drilling, rock		0.0212
Blasting rock		0.0715
Removal of spoil		0.3091
Total for 550,127 cubic yards		$0.4902

This cost does not include interest or depreciation.

SCRAPER EXCAVATOR

A power operating grader was worked successfully in constructing the Tacoma and Eastern Railway in Washington. The device consisted of a riveted sheet steel scraper of special construction operated by a double drum engine through a hauling rope and a pull back rope. The scraper consisted of two vertical side plates with the front ends cut square and the rear ends to a semi-circle. Connecting the semi-circular rear ends across the scraper was a half-cylinder of steel plate with top and bottom edges shod with cutting knives. To keep the front ends of the side plates rigid they were braced together by a cross-strut. They also had bail connections on top and bottom. In operation the scraper was pulled ahead and the bottom knife edge shaved off a strip of earth which piled against the hollow back plate and was dragged along to the dumping bank. By having two knives the scraper could be reversed, top for bottom, when one knife was dull, by simply shifting the bail. Dumping was accomplished by simply pulling the scraper back from the load. These machines are made in two sizes: 5 ft. wide, 30 ins. high and 6 ft. long, for 5 cu. ft. capacity, and 7 ft. wide, 36 ins. high and 9 ft. long for 7 cu. ft. capacity. For the smaller size a 9x10 in. engine is required and for the larger size a 10x15 in. engine. The hauling line should be 1 in. steel cable and the pull back line ⅞ in. steel cable. Ordinarily it takes three minutes to haul

800 to 1000 feet. The price of the scraper is $250.00 for the smaller size and $300.00 for the larger size.

The Drag Scraper Excavator* has been used with great success on the New York Barge Canal. Where canals are being dug and a large waste bank must be built, or where a heavy fill is to be made in ground which is average and has no large boulder or tree stumps, this machine is very successful. The scraper bucket is suspended by cables from the end of a long boom. Booms 90 ft. or 100 ft. long, giving a reach of 100 or 110 ft. from the center of the machine to the end of the boom, are practicable. The entire machine swings on a circular turntable. The bucket is filled by pulling it directly toward the center of the machine by means of a cable so there is no strain on the boom except that due to its own weight and the weight of the bucket and its load. As a result the booms of this type of machine can safely be made lighter and consequently longer than is the case with the booms of dipper dredges of similar size and strength. A machine of the type illustrated (Fig. 118),

Fig. 118. Drag-Scraper Excavator Used on New York Barge Canal.

used on the New York Barge Canal, has an 85 ft. boom, a reach of 96 feet and weighs 147 tons. A 2 yd. dipper is used which in operation is usually filled full and sometimes carried 4 yds at a load. The engine is of 15 H. P. capacity and the boiler 54 H. P. The machine is probably strong enough to operate a 3¼ yd. dipper. It excavated earth 90 ft. from the center of the machine on one side and deposited 100 ft. from the center on the other side. It can deposit material on banks from 20 to 35 ft. in height. A machine is usually moved forward by means of cables.

*Compiled from U. S. Dept. of Agr., Bul. 230.

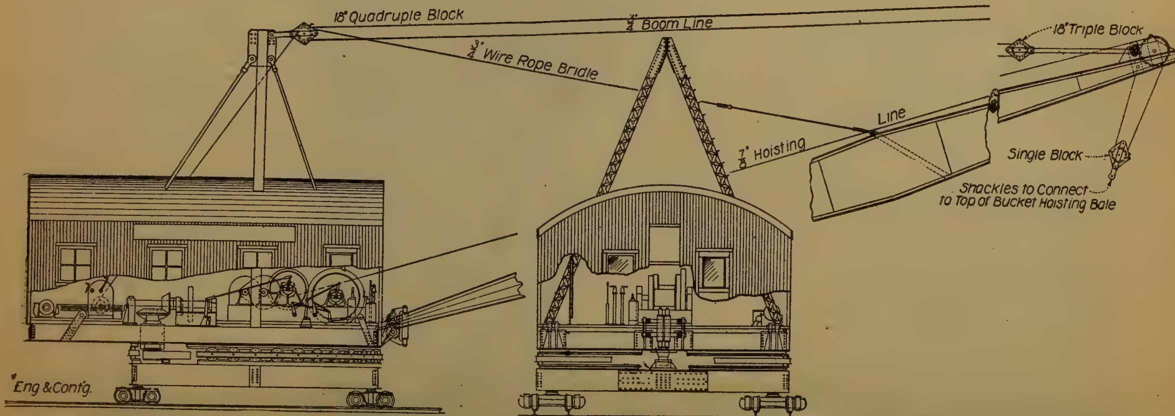

Fig. 119. Arrangement of Operating Machinery of Electrically Operated Dragline Excavator.

During May, 1910, the items of cost of operation were as follows:

Engineer, at $90 per month	$ 90.00
Engineer, at $95 per month	84.04
Firemen, pumpmen, watchmen and laborers at $1.75 per day	363.00
Coal, at $3 per ton	147.00
Repairs	15.82
Total	$699.86

The first cost of this machine was $10,000. Table 119 gives the cost of operation of this machine on the New York Barge Canal:

TABLE 119

Item	April	May	June	July	August
Fitting up	$426.80	......	......	....	....
Excavation	319.74	$684.29	$747.77	$ 850.69	$1,118.57
Repairs	.....	15.82	62.60	48.23	75.12
Interest and depreciation, 21%	175.00	175.00	175.00	175.00	175.00
Shifting on work	.....	*	......	77.02	....
Total	$921.54	$875.11	$985.37	$1,150.94	$1,368.69
Average cost per yd.	$0.177	$0.048	$0.0388	$0.0348	$0.0289
Yards complete during month	5,205	18,365	25,333	33,055	47,363

* Machine fell into canal.

Electrically Operated Drag Line Machines. Average cost for the season, including all charges, 4.1 cts. per yard. Two large electrically operated drag line scrapers were used on the Calumet Sag Channel near Chicago. These machines had 100 ft. steel booms and were equipped with 2½ cu. yd. scraper-buckets, and each weighed about 120 tons. The following description is reprinted from *Engineering and Contracting*, Jan. 22, 1913:

The arrangement of the operating machinery is shown in the accompanying drawing (Fig. 119). The double drum hoist is operated directly by a gear on the shaft of a 112 H. P., 60-cycle, 3-phase motor, making 690 r. p. m. A 52 H. P., 60-cycle, 3-phase motor, 855 r. p. m., operates the bevel swing gear as shown. The air brakes are operated through power furnished by a 25 cu. ft. motor-driven air compressor. The current is furnished by a public service company and is brought from Blue Island, several miles away, over a high tension line at 33,000 volts to a transformer house on the work where the voltage is stepped down to 2,300 volts. It is again stepped down to 440 volts through a portable transformer which is attached to the dragline machine by a cable and is pulled along on its trucks as the machine moves ahead. On the machine the current is stepped down to 110 volts for the incandescent lamps and to 35 volts for the searchlight which is placed on the front of the house and just under the boom.

The machine is operated by two men on board and two men

outside for handling the track. While moving to position for commencing work one of the machines was moved 410 ft. in one day. The track sections upon which the machine runs are 15 ft. long and are built up solidly. They are built of a solid 3-in. plank bottom upon which are fastened the ties set about 8 ins. apart. On top of the ties are 8x16 in. timbers on edge under the 90-lb. rails. The whole is bolted together and has eyebolts near the ends of the 8x16 in. timbers so that it can be handled by a four-way chain.

The work upon which the machines are engaged consists of about 8,000 ft. of canal section from 31 to 37 ft. deep, 36 ft. wide on the bottom and with slopes of 2 on 1. The south berm will be about 90 ft. wide or will extend 150 ft .from the center line of the canal and the north berm will be 40 ft. narrower, according to the plans. About 8 to 12 ft. of the bottom work on Section 5 will be rock and it is not yet decided by the contractor how this will be handled, though it is likely to be handled in skips by a derrick with a very long boom. The dragline machines are set on opposite banks. The one on the south will excavate half the canal section in two cuts.

That the use of electricity will be economical is illustrated by machines in California which actually used ⅕ of a K.W.H. per cubic yard of material handled. The cost of the current there was on a sliding scale ranging from ¾ to 1 ct. per kilowatt hour. On the New York Barge Canal electrical machines were used where the cost of current at about 2½ cts. per kilowatt hour was about 1 ct. per cubic yard.

The reliability of the power is a most important argument in favor of the use of electricity. The uncertainty of securing fuel and water, especially in bad weather, is a source of trouble to the contractor.

The cost of hauling coal for a steam machine of this size would likely amount to $40 per day, and the coal itself (about 10 tons) would cost about $30. These items are eliminated where electricity is used, and the cost of the current is substituted.

A Dragline Scraper Excavator having novel features is used on one of the New York State Barge Canal contracts held by the Atlantic, Gulf & Pacific Co., New York City. This excavator is known as a Field Tower Scraper, being named from its inventor, the superintendent for the company at Comstock, N. Y. As shown by Fig. 120, the essentials of the excavator are a movable tower, a cableway and hauling lines and a special scraper bucket. The tower carries a double drum engine. From one drum a line passes up the tower and over a sheave located from one-fourth to one-third its height and thence down to the bucket. This is the hauling line. The second line passes up and over a tower head sheave and thence to a pulley block on the opposite side of the prism. This pulley block rides on a ½-in. cable about 200 ft. long, stretched parallel to the prism between two deadmen, moving along the cable as the tower moves. This second line is the cableway on which the scraper bucket travels back and forth

across the canal, being pulled toward the tower by the hauling line and sliding back by gravity.

The Tower. The tower is a framed timber structure of height suitable to cover the width of the excavation for which it is intended (the standard tower being 75 ft. in height). This tower

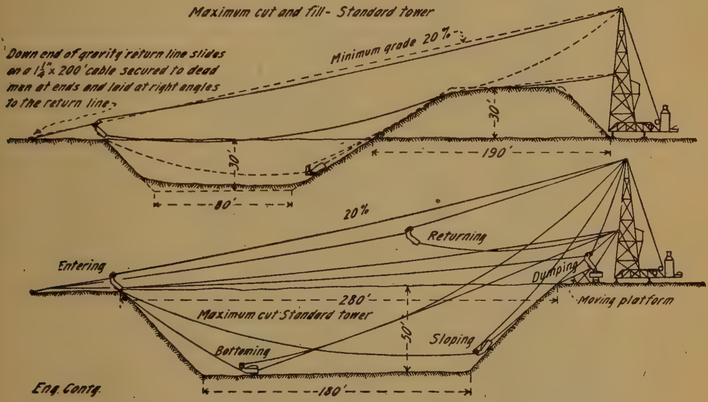

Fig. 120. Sketches Showing Operation of Field Tower Excavator.

rests on a trussed platform or car which carries the hoisting engine, coal and other supplies. The tower is rigidly secured to the truss and guyed by back stays to the projecting back end of the platform. The platform or car runs on four solid double flange cast steel wheels, 16 ins. in diameter and 4 ins. tread. The track consists of two 90-lb. rails each spiked to 6 x 8 in. x 4 ft. ties spaced 2 ft. apart and bolted to two 2 x 12 in. x 30 ft. planks. The engine may be any good make 10 x 12 in. engine with double drums and two niggerheads. The hauling line is ⅞ in. and return cable is ¾ in.; 18 in. sheaves are used.

The tower is moved forward or back by a 1½ in. manila line secured to a deadman suitably placed, passing through sheaves secured to the platform and around the niggerhead. The track is also moved ahead by the same means, the deadman being dispensed with and line passing around the end of a boom which is a part of the tower. The line around the niggerhead is operated by the fireman.

The operator's cabin is placed up about one-third the height of the tower in full view of the work, and the engine is manipulated by suitable levers and brakes connecting the operating cabin with the engine.

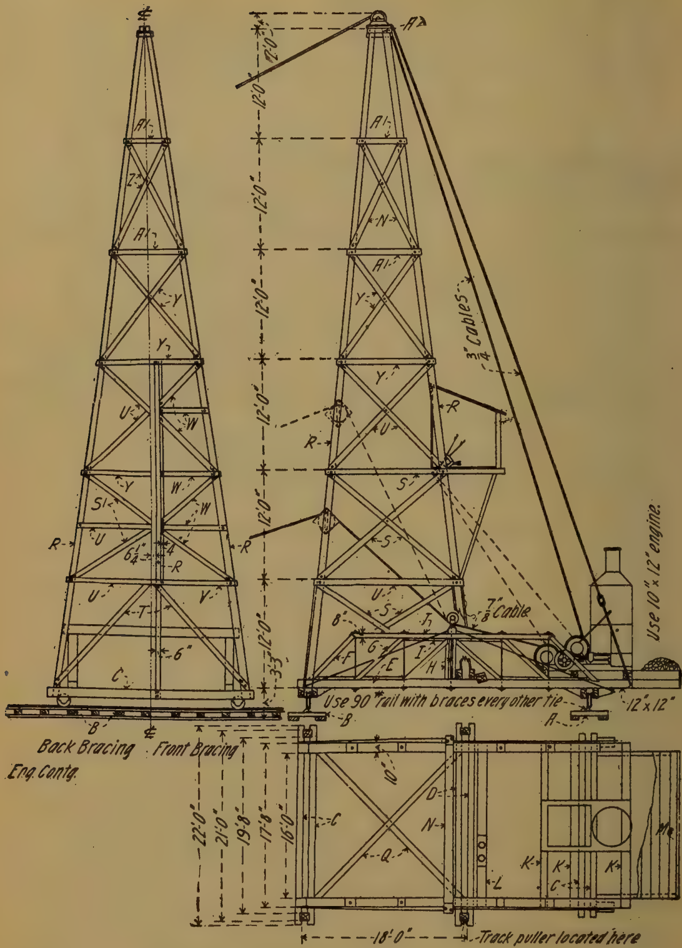

Fig. 121. Details of Tower for Field Tower Excavator.

Scraper Bucket. The distinctive feature of the excavation is the scraper bucket which is shown by Fig. 122. This bucket has a capacity of 48 cu. ft. level full, but in ordinary material it will "crown up" to 2 cu. yds. capacity. Particularly easy and certain control are claimed for this bucket. These advantages are brought about by the combination of two sheaves placed at the rear end of the scraper at right angles and vertically to it, the return line passing reversely over the upper and under the lower sheave, while the bottom of the scraper is fitted with two curved cradles or shoes, resulting, in connection with the pulling line, in such control of the cutting edge that the scraper can be sustained at any vertical angle at the will of the operator.

Cost Data. The chief first cost of this plant is in the hoisting engine and cable, which are all standard commercial designs and usable for other purposes. The following is an estimate furnished by the Atlantic, Gulf & Pacific Co. of the cost of a tower scraper plant, including everything:

5,080	ft. B. M. lumber at $38 per M	$ 193.04
360	ft. B. M. white oak at $45 per M	16.20
540	lbs. iron bolts and nuts at 6 cts	32.40
120	ft. ⅝ in. wire rope backstays	13.20
2	⅝ in. turnbuckles	.80
1	headblock sheave and bearing	10.00
1	hauling sheave and bearing	4.00
1	8¼x10 Lidgerwood double drum hoisting engine	1,089.00
1	scraper bucket, complete with cutting edge, sheaves, etc.	300.00
	Labor directing based on condition in northern New York, carpenters at $2.50 per 8-hour day	200.00
	Total	$1,858.64

The following is an estimate of the operating cost of the plant also furnished by the Atlantic, Gulf & Pacific Co.:

Item.	Cost per Month.
Wire rope	$160.00
20 tons coal at $4	80.00
Oil, waste and repairs	15.00
Total	$255.00

To this is to be added the labor cost. Each shift requires the following force:

1 foreman at 37½ cts. per hour	$ 3.00
1 engineer at 37½ cts. per hour	3.00
1 fireman at 22 cts. per hour	1.76
1 signal man at 25 cts. per hour	2.00
5 laborers at 20 cts. per hour	8.00
And an additional	
4 laborers at 20 cts. per hour	6.40
Total	$24.16

Assuming 26 working days and two shifts per day, the labor cost for one month is $1,256.32, which, added to $255 given above, makes a total cost for operation of $1,511.32. Assuming interest on plant at ½ per cent per month we have an additional $9.30, making the grand total $1,520.62. Assuming an output of 700 cu. yds. per day we get a cost per cubic yard of 8.4 cts. This cost included, however, a proportion of the field office expenses. In regard to the life of the cables used, the Atlantic, Gulf & Pacific Co. writes:

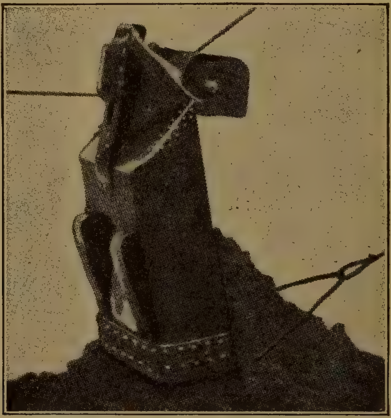

Fig. 122. Scraper Bucket for Field Tower Excavator.

"While the life of the wire rope used depends almost entirely upon the character of material to be excavated; in clay and loam, the plant working two eight-hour shifts per day, 26 days each month, excavating approximately 700 cubic yards per day, will use 800 to 1,000 ft. of wire rope per month."

TABLE 123A—BILL OF MATERIAL FOR FIELD TOWER.

Mark.	No.	Size.	Length. Ft.	Length. In.	Ft. B. M.	No.	Size of Bolts.	Washers.
A	4	4"x12"	30	0	480	44	⅝"x10" wood	88 cut
B	22	6x 8	4	0	352	16	1x20	32 cast
C	4	8x12	22	0	504	8	1x20	16 cast
D	2	6x12	22	0	264	8	1x24	16 cast
E	2	12x12	36	0	864	8	1x16	16 cast
F	4	8x12	8	0	256	8	½x6'–6" long	14 1"x 6"x12"
G	8	6x12	7	0	336	2	1½x7'–6" long	4 1"x10"x12"
H	4	4x10	5	0	67	..	....	2 1"x22"x12"
I	12	3x10	5	0	150	4	2"x19'–0" long	....
J	2	8x12	22	0	352	12	1"x20" wood	24 cast
K	3	12x12	18	0	648	4	1"x20" wood	8 cast
L	1	10x12	18	0	180	8	1"x14" wood	16 cast
M	11	3x12	16	0	528	..	....	....
N	1	10x10	20	0	167	3	1"x14" wood	....
O	1	8x 8	24	0	128	1	1"x12" wood	2 cast
P	1	3x 6	18	0	27	8	1"x16" wood	16 cast
Q	2	8x10	22	0	322	..	....	....
R	..	2x 8	..	0	2200	150	½"x8" wood	300 cut
						24	½"x12" wood	48 cut
S	12	3x 6	20	0	360			
T	4	6x 6	16	0	192			
U	18	3x 6	18	0	486			
V	1	6x 6	19	0	57			
W	14	3x16	10	0	210	16	⅝"x14" wood	
X	1	6x 6	12	0	36	150	½"x9" wood	350 cut
Y	11	3x 6	16	0	264			
Z	8	3x 6	14	0	168			
A¹	8	3x 6	10	0	120			
A²	1	12x12	3	0	36	4	¾"x16" & 2¾"x3"x4"	
"	4	4x 8	3	0	32	4	¾"x2'–6"	....
"	1	4x12	6	0	24	2	¾"x3'–3"	18 cast
"	2	7x 8	3	0	30	2	¾"x20"	
Housing 1" and 2"x4"					3000	..	....	
					12840			
Wheel boxes						32	¾"x17"	
Idler						4	¾"x12"	36 cast
Cable clips						12	¾"	
Turnbuckles with eyes						2	¾"	....
Back stay						..	160' ⅞" cable	....

Lever connections not included.

The Tower Excavator.* The principal parts of this apparatus are a hoisting engine; a tower 65 ft. high, guyed to cables extending to the ground on each side, where instead of being

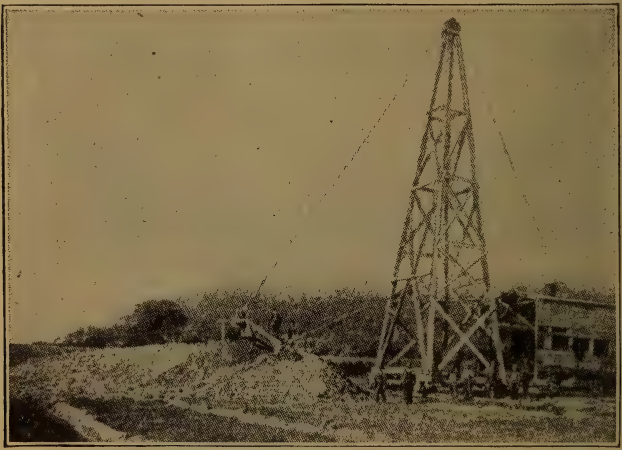

Fig. 123. Tower Drag-Scraper Excavator.

stationary, they slide on other cables stretched parallel to the ditch and fastened to deadmen, thus giving stability to the tower, while allowing it to move parallel to the ditch; the scraper

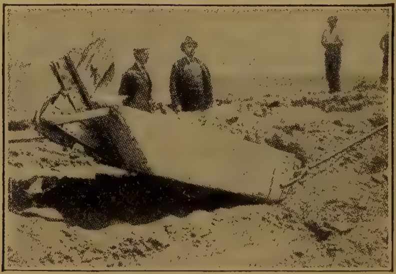

Fig. 124. Bucket Used with Tower Drag-Scraper Excavator.

bucket in which the earth is moved; and cables for operating the bucket. The machine is built upon a platform and is moved on rollers by winding a cable fastened at one end to a deadman.

* Abstracted from *Engineering News.*

A more efficient provision for moving the machine would doubtless result in considerably reducing the cost of operation. The operation of the machine is illustrated in Figs. 123 and 124. Its cost is about $1,500. With the strengthening of parts necessary to fit it for extra heavy work the cost would be about $2,000, of which $1,200 would represent the cost of a hoisting engine.

In operating the excavator the bucket is loaded by pulling it toward the tower by winding up the cable, which, passing over the lower sheave on the tower, is attached to the front end of the bucket. The bucket is then dumped by winding over the drum the cable which passes over the sheave on top of the tower and which is attached to the back end of the bucket. The bucket is returned to the ditch by further tightening the upper cable and loosening the lower one, then it quickly slides back by gravity to the starting point. The earth is deposited between the ditch and the machine.

The following is the cost for each eight hour shift in operating this machine:

Engineer	$ 3.00
Fireman	2.00
Foreman	3.00
Signal man	2.00
Cable shifter	1.60
Horse and man, moving track	3.00
4 Laborers, at $1.60 each	6.40
1½ tons of coal to the shift, at $3 per ton	4.50
Total	$25.50

If to this is added $1.50 per shift for maintenance, depreciation, interest, and repairs at the rate of 50 per cent per annum on the original cost of the investment, the total cost per shift is $27.

By arranging for the operator to work from a station in the tower, where the work would be in full view, the signal man would be eliminated, and by placing the machine on a track with an arrangement for moving the machine ahead on the work by means of gearing attached to the axles probably two or three more men could be dispensed with, thus further reducing the cost.

The bucket used on this machine had a capacity of about 2 yds., but in ordinary operation at least 3 yds. were carried at each load. While in operation about 1 bucketful was excavated and deposited in each forty seconds. This would make a rate of 4 cu. yds. a min., and the contractor was of the opinion that he could maintain an output of 1,000 yds. per eight-hour shift for an entire season's run on continuous work of a favorable character. The work actually done was not carried on continuously, and the best record made was 40,000 cu. yds. per month for two shifts for one machine. At a cost of $50 a day for two shifts this would amount to about 3 cts. per yd. for the month's work.

The machine has a reach of 210 ft. from the far side of the ditch to the near side of the waste bank. That is, all the dirt must be excavated and deposited in a space of 210 ft., making a

waste bank about 20 ft. high if necessary. The bucket is remarkably well under control.

This machine was in many ways crudely built, and its excellent record is due apparently to the exceedingly simple principle of its operation, and to the economy of power, motion and time in excavating. The bucket moves on a straight line, across the excavation and onto the waste bank, and when dumped slides with great rapidity down the tightened cable to the position for digging.

With a construction including modern devices for moving on the work and the improved bucket, it seems that this should be a very important addition to the types of excavating machinery. It is fitted for digging ditches 20 to 100 ft. wide and 2 to 30 ft. deep, though its greatest economy of operation is in constructing the larger sections.

EXPLOSIVES

Nature of Explosive Action. The value of explosives in construction work is derived from the volume of gas generated upon detonation or explosion, and the speed at which the generation takes place. The pressure of the generated gases is equal in all directions (contrary to the belief of many "practical men"), but a slow burning black powder will take many times as long to generate the gas as a detonant like nitroglycerine. Dynamite will shatter a rock without even a mud cap, because the gases are liberated with such extreme velocity that the effect is produced on the rock before the atmospheric air can overcome its own inertia and yield.

Gunpowder. There are the following general classes of black powder manufactured:

Nitre Powder, the highest grade, consists of 75 per cent saltpetre (KNO_3), 15 per cent charcoal, and 10 per cent sulphur. It usually comes in 25 lb. kegs, and costs about $2.10 per keg.

Soda Powder contains sodium nitrate ($Na\ NO_3$), which deteriorates in time by absorbing moisture from the air. It usually comes in 25 lb. kegs and costs about $1.25. The average weight of loose powder, slightly shaken, is 62½ lbs. per cu. ft., or 1 lb. occupies 28 cu. ins.

Judson Powder, which is a free running black powder, comes in 50 lb. kegs and costs about $7.25 and under. It is a soda powder and contains from 5 to 10 per cent of nitroglycerine.

Nitroglycerine	5%
Sodium nitrate	64%
Sulphur	16%
Cannel coal	15%

Dynamite consists of any absorbent or porous material saturated or partly saturated with nitroglycerine. The absorbent is called the "dope." If 40 per cent of the weight of dynamite is nitroglycerine it is known as 40 per cent dynamite; if 75 per cent, it is known as 75 per cent dynamite.

High explosives are usually packed in cases containing 25 and 50 lbs. "Car load" means 20,000 pounds dynamite net weight, except where the railroad requires a larger minimum quantity, in which event that minimum quantity is considered a car load. Prices on 200 pounds or more usually include delivery to the nearest freight station. The prices of high explosives vary in the different sections of the country as much as $4.00 or $5.00 per one hundred pounds. For instance, in greater New York and most points in Colorado and Florida they are high; in Maryland, Pennsylvania and the greater part of New Jersey they are low as a rule. The price in any section is liable to change without notice and their variation is due to many different causes, such as high or low freight rates, local ordinances regarding the method of delivery, etc., hence, the rates given below are aver-

age and are mainly of use in determining the relative prices of different kinds and grades of explosives.

			Cents per Lb. Car-loads, 20,000 Lbs.	2,000 Lbs. or Over	Less Than 2,000 Lbs.
Atlas, Hercules, Giant & Red Cross (latter not less than 20%) from 15% to 60%	Nitroglycerin grades only	15%	10.00	11.75	12.50
		17%	10.15	11.90	12.65
		20%	10.40	12.15	12.90
	Nitroglycerin, Semi-Gelatin and Ammonia grades only	25%	10.80	12.55	13.30
		27%	10.95	12.70	13.45
		30%	11.20	12.95	13.70
		33%	11.45	13.20	13.95
	Nitroglycerin, Semi-Gelatin, Gelatin and Ammonia grades	35%	11.60	13.35	14.10
		40%	12.00	13.75	14.50
		45%	12.50	14.25	15.00
		50%	13.00	14.75	15.50
		60%	14.00	15.75	16.50
Repanno, Forcite, Giant & Hercules from 35% to 80%	Gelatin grades only	70%	15.00	16.75	17.50
		75%	15.50	17.25	18.00
		80%	16.00	17.75	18.50
	Blasting Gelatin		21.50	23.25	24.00
	Carbonite Nos. 1 & 2		12.00	13.75	14.50
	Carbonite, Nos. 3 & 4		11.20	12.95	13.70
	Monobel, Nos. 1, 2 & 3		13.00	14.75	15.50
	Judson R. R. P.	5%	8.50	9.50	10.00
	Judson F	10%	9.50	11.25	12.00
	Judson FF	15%	10.00	11.75	12.50
	Judson FFF	20%	10.40	12.15	12.90

Red Cross Explosives are especially valuable in cold weather because although they will freeze, they do not freeze readily and will thaw when ice melts. Identical in appearance and similar in action to other standard grades.

Ammonia Dynamite has a strong heaving and rending effect, producing a minimum of fine material. Fumes not objectionable. Difficult to ignite by "side spitting" of fuse. Suitable for open or underground work.

Semi-Gelatin is an excellent explosive for wet work. No objectionable fumes.

Gelatin Dynamite is dense, plastic,- fumes not objectionable. Little affected by water.

Blasting Gelatin is a very high power, quick-acting explosive with good water resisting qualities and a lack of objectionable fumes. For use in rock too hard for 80 per cent Gelatin Dynamite.

A "permissible explosive" is one which has been approved by the United States Government as "permissible for use in gaseous or dusty coal mines."

Monobel No. 2 and Carbonite No. 1, are recommended for anthracite coal, bituminous coking coal and other coal where a quick acting explosive is needed.

Monobel No. 3 and Carbonite No. 4 are slower in action, and should be used where a maximum of large lump is desired.

Carbonite No. 2 is slower than No. 1 and quicker than No. 3.

Monobel No. 1 is designed for use in quarries and ore mines. It does not require thawing, and is practically fumeless.

Judson powder is intermediate between dynamite and blasting powder. It is especially valuable in soft and friable work. Judson R. R. P. has already been described.

Judson F, FF and FFF are put up in cartridges like dynamite.

The weight of dynamite per inch of stick is about as follows, and all of the grades weigh about the same per stick:

Diam of Stick (Ins.)	Wt. per In. of Length (Lbs.)
1	0.042
1¼	0.065
1½	0.094
1¾	0.128
2	0.168
2¼	0.212

TABLE 120—TABLE OF OUTSIDE DIMENSIONS AND SHIPPING WEIGHTS OF CASES.

Explosive	Case No. 1, Capacity 50 Lbs. Net — Wt. Lbs.	Case No. 1 — Dimensions L. W. D.	Case No. 2, Capacity 50 Lbs. Net, in Cartons — Wt. Lbs.	Case No. 2 — Dimensions L. W. D.	Case No. 3, Capacity 25 Lbs. Net — Wt. Lbs.	Case No. 3 — Dimensions L. W. D.	Case No. 4, Capacity 25 Lbs. Net, in Cartons — Wt. Lbs.	Case No. 4 — Dimensions L. W. D.
Nitroglycerin Dynamite	58	17½x12 x 9	60	25½x 9¾x9	29½	13½x9½x8		
Extra Dynamite	58	17½x12 x 9	60	25½x 9¾x9	29½	13½x9½x8		
Gelatin Dynamite	58	17½x12 x 8	60	25½x 9¾x9	29½	13½x9½x8		
Blasting Gelatin	58	17½x12 x 8			29½	13½x9½x8		
Judson R.R.P. (bags)	59	17½x12 x11¼			29½	13½x9½x8		
Judson Powder	58	17½x12 x 9						
Monobel No. 1			65	18½x16¾x9¾			34	16¾x10 x9¾
Monobel No. 2			65	18½x16¾x9¾			34	16¾x10 x9¾
Monobel No. 3			65	18½x16¾x9¾			34	16¾x10 x9¾
Monobel No. 4			65	18½x16¾x9¾			34	16¾x10 x9¾
Monobel No. 5			65	18½x16¾x9¾			34	16¾x10 x9¾
Carbonite No. 1	58	17½x12 x 9	65	25½x 9¾x9½	29½	13½x9½x8	32	14 x 9¾x8½
Carbonite No. 2	60	17½x13½x11¼	65	18½x16¾x9¾	31	19 x9½x8	34	16¾x10 x9¾
Carbonite No. 3	60	17½x13½x11¼	65	18½x16¾x9¾	31	19 x9½x8	34	16¾x10 x9¾
Carbonite No. 4	58.5	17½x13 x 9			31	14 x9¾x8½	32	14 x 9¾x8½
Carbonite No. 5	60	17½x13½x11¼	65	18½x16¾x9¾	31	19 x9½x8	34	16¾x10 x9¾
Carbonite No. 6	60	17½x13½x11¼	65	18½x16¾x9¾	31	19 x9½x8	34	16¾x10 x9¾

EXPLOSIVES STORE HOUSES

Professor Courtenay de Kalb, in his "Manual of Explosives," says:

"Storage (of explosives) in caves, tunnels, earth or stone covered vaults and in log structures should under no circumstances be tolerated. The chief objection in all these cases is that the structure will hold dampness, and any dampness in a magazine containing any explosive into which nitrates enter as an essential or accessory ingredient is certain to affect its quality and render it more or less dangerous in subsequent use. This applies to gunpowder (common black powder) and to practically all dynamites . . ."

Professor de Kalb recommends a building of tongued and grooved boards, blind nailed, with tar-paper covered roof, and if danger of fire is apprehended, steel shingled covered roof and walls. An ordinary tool box covered with tin or sheet iron and painted red with large, distinct "danger" signs on all sides is excellent. However, it is possible to obtain ready made magazines.

In a recent catalogue of the Du Pont de Nemours Powder Company a number of storage houses are described, and the following data are compiled.

On October 1, 1911, Massachusetts, New Jersey, Ohio, California, and Oklahoma had laws regulating distances at which specific quantities of explosives might be stored with reference to dwellings, public buildings, railroads, etc. Almost all cities and towns have laws regarding this and all who intend to store explosives should inform themselves on all state and local laws. Where no laws affecting storage of explosives are in force, we recommend that magazines be located in compliance with the American Table of Distances, to-wit:

TABLE 121

Pounds of Explosives.	Distances to Inhabited Buildings When Magazine Is Barricaded. (Feet.)	Distances to Unprotected Inhabited Buildings (Ft.).	Distances to Passenger Ry's. When Magazine Is Barricaded (Ft.)	Distances to Unprotected Passenger Ry's. (Feet).
100	180	360	110	220
200	260	520	155	310
300	320	640	190	380
400	360	720	215	430
500	400	800	240	480
600	430	860	260	520
700	460	920	275	550
800	490	980	295	590
900	510	1,020	305	610
1,000	530	1,060	320	640
1,500	600	1,200	360	720
2,000	650	1,300	390	780
3,000	710	1,420	425	850
4,000	750	1,500	450	900
5,000	780	1,560	470	940

Where municipal regulations do not prohibit storing explosives within city limits, powder or dynamite in quantities of 100 pounds or less may be kept in a small portable magazine. Always mark on this magazine the words "Powder Magazine." Fuse may be kept in store and blasting caps or electric fuses, not exceeding 500 each. Always keep magazine locked.

Sidewalk Magazine Without Wheels. A magazine built of 2-in. boards covered entirely on the outside with No. 20 flat iron, having the lid secured by ordinary hinges and fitted with hasp, staple and padlock. (No magazine should be allowed to rest on the ground because powder absorbs moisture.).

COST

For 50 lbs. powder, 22" wide x 27" long x 17" high....	$ 5 to $10
For 100 lbs. powder, 27" wide x 27" long x 22" high....	6 to 12
For 50 lbs. dynamite, 19" wide x 28" long x 13" high..	6 to 12
For 100 lbs. dynamite, 19" wide x 28" long x 22" high..	7 to 14
For 200 lbs. dynamite. 25" wide x 36" long x 22" high..	9 to 18
For 300 lbs. dynamite, 25" wide x 50" long x 22" high..	11 to 22

Sidewalk Magazine with Wheels. Similar to that without wheels, but supplied with four 6-in. cast iron wheels on the outside at the bottom.

COST

(Has same dimensions as those without wheels)

For 50 lbs. powder..................................	$ 6 to $12
For 100 lbs. powder..................................	7 to 14
For 50 lbs. dynamite................................	7 to 14
For 100 lbs. dynamite................................	8 to 16
For 200 lbs. dynamite................................	10 to 20
For 300 lbs. dynamite................................	12 to 24

Iron Magazines for storing explosives are of two kinds; the portable sidewalk magazine on wheels, and the storage magazine. The former is furnished in five sizes from that with a capacity of eight kegs, size 24"x23"x25", weight 150 pounds, price $15 f. o. b. Ohio, to that with a capacity of thirty kegs, size 30"x30"x50", weight 450 pounds, price $37.50. The latter kind comes in ten sizes, from the smallest, capacity 108 kegs, size 3'x6'x6', weight 700 pounds, price $56.25, to the largest, capacity 1,848 kegs, size 11'x8'x21', weight 4,400 pounds, price $337.50.

General Specifications for Sand Filled Dynamite Magazine are as follows:

Foundations:	If a post foundation is used, posts spaced 5 ft. c. to c. and charred or tarred. If brick foundation is used, 9-inch wall stepped to 12 or 15 inch- footing course, all laid with lime or cement mortar. If stone foundation is used, wall may be laid dry. If concrete foundation is used, wall need not be more than 8 inches thick.
Floor:	Joists: 2 in.x6 in., spaced 12 in. c, to c. Floor: ⅞-in. matched boards, blind nailed, or 1-in. board with nails countersunk.

Sills and Plates:	2x6 in.
Studding:	2x6 in.
Siding:	⅞-in. tongue and groove, or shiplap.
Lining:	Sheath inside of building from sills to plate with ⅞-in. tongue and groove blind nailed, or shiplap with nails countersunk.
Bullet Proofing:	As inside sheathing is put on fill space between the sill, plate, studding, outside and inside sheathing with coarse sand, well tamped. Do not use gravel or stone.
Roof:	Rafters: 2x4 in., spaced 24 in. c. to c. Sheathing, 1-in. plank.
Roofing:	No. 24 galv. corrugated iron.
Cornice:	(Under eaves) No. 26 galv. flat iron. To make roof bullet-proof from above, nail plank on rafters and fill with sand.
Iron Covering:	Sides and ends to be covered with No. 24 or No. 26 black or galv. flat or corrugated iron.
Door:	3-in. hardwood, covered on outside by ⅜x62x40 in. steel plate. All hinges to be secured by bolts passing through to inside.
Ventilation:	3-in. or 4-in. globe ventilator in roof. Ventilator holes to be cut in foundation.

COST.

For storing 1,000 lbs., size 6x6 ft.	$40 to $ 60
For storing 2,000 lbs., size 6x7 ft.	50 to 80
For storing 3,000 lbs., size 7x7 ft.	60 to 90
For storing 4,000 lbs., size 7x8 ft.	70 to 100
For storing 5,000 lbs., size 8x8 ft.	80 to 120

Distance from ground to floor, 3 feet. From floor to eaves, 6 feet.

Brick Magazine. These have 8 in. walls, have floors of and are lined with ⅞-in. plank, and have roof covered with corrugated galvanized iron.

COST

For storing 1,000 lbs., size 7x 6 ft.	$ 60 to $ 80
For storing 2,000 lbs., size 7x 7 ft.	70 to 100
For storing 3,000 lbs., size 7x 8 ft.	80 to 110
For storing 4,000 lbs., size 7x 9 ft.	90 to 130
For storing 5,000 lbs., size 7x10 ft.	100 to 140

FIRE EQUIPMENT

CHEMICAL ENGINES.

This engine, Fig. 125, has proved to be a most valuable piece of fire fighting apparatus for use in warehouses, factories, lumber yards, private residences, etc.

The construction consists of a forty gallon steel cylinder,

Fig 125. Chemical Engine.

tinned inside and out, set up on two suitable wheels 42 inches in diameter, either of the sarvan or all-steel wide tire pattern, the cylinder being properly balanced between the two wheels so that when the engine is set upright on its bottom the wheels clear the floor or ground; suitable handles are provided by which the engine is easily run from place to place and when required for village fire department use a suitable drag rope is furnished.

The equipment consists of 50 ft. ¾ in. chemical hose with

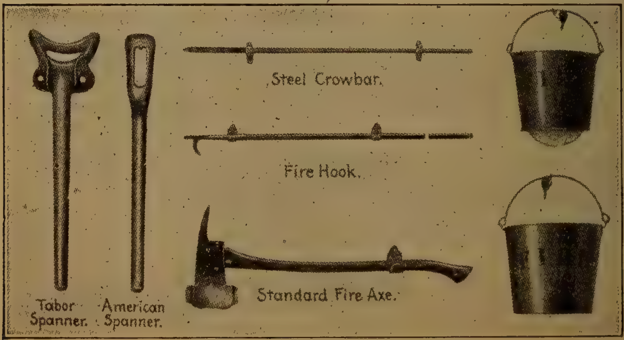

Fig. 126. Standard Underwriter Equipment.

couplings and shut-off nozzle. Dimensions, height 52 inches, diameter 16 inches, width over hubs of wheels 35 inches, track 29 inches.

Finished in aluminum, bronze or any color Japan.

Charge consists of 17 lbs. bi-carbonate of soda and 10 lbs. sulphuric acid.

The price of this engine, tinned inside and out is $175.00 net, lead lined, $210.00 net.

STANDARD UNDERWRITER EQUIPMENT.

(As illustrated in Fig. 126.)

	Price Net
Steel crowbar	$ 1.50 each
Fire hooks, 6 ins. long	1.25 each
Fire hooks, 12 ins. long	1.75 each
Fire hooks, 16 ins. long	3.50 each
Fire axe with pick back, heavy	21.00 doz.
Fire axe with pick back, light	16.80 doz.
Fire axe holder, polished brass	.90 set
Tabor hose spanner	2.10 doz.
American hose spanner	2.10 doz.
Galvanized iron pails, 12 qts	3.00 doz.
Galvanized iron pails, 12 qts., round bottom	4.35 doz.

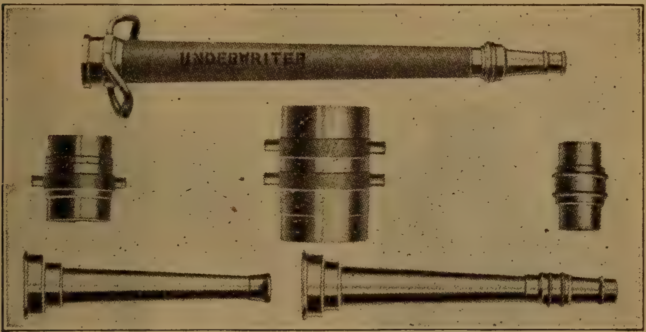

Fig. 127. Hose Nozzle and Expansion Ring Couplings.

TABLE 121—HOSE NOZZLE AND EXPANSION RING COUPLINGS.

Hose Nozzles, Plain.

Size (Ins.)	Length	Price per Doz.
¾ net	6	$ 2.80
1	8	3.60
1½	10½	7.20
2	11	11.40
2½	12	18.24

Hose Nozzles, Screw Tip.

Size Coup. (Ins.)	Length	Price per Doz.
¾	8	$ 4.00
	12	5.00
1	8	5.00
	12	6.00
1½	12	12.50
	20	18.00
2	12	19.00
	20	25.00
2½	15	26.25

EXPANSION RING HOSE COUPLINGS.

1½ in.	$0.95 net.	Medium 2 in.	$2.00 net
Medium 1½ in.	1.60 net.	2½ in.	1.35 net
2 in.	1.05 net.	Medium 2½ in.	2.60 net

EXTRA HEAVY EXPANSION RING COUPLINGS.

		Price
Underwriter Approved Type	per set net	$2.10
Fire Department Service	per set net	2.10
Navy Bronzed Pattern	per set net	3.10
Mill Type		1.85

FIRE EXTINGUISHER.

Made in three gallon size (Fig. 128). Guaranteed tested 350 lbs. pressure.

	Price, Net
3-Gallon, polish copper	$9.00
3-Gallon, red Japanned	9.30
3-Gallon, nickel plated	9.60

Fig. 128.

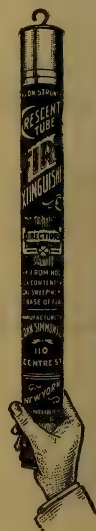

Fig. 129.

TUBE FIRE EXTINGUISHER, DRY POWDER.

The Dry Powder Fire Extinguisher, illustrated (Fig. 129), consists of a tube 22 inches long and 2¼ inches in diameter, filled with a dry chemical compound, the chemicals being deadly to fire but absolutely harmless to anything else. Price, $1.05.

Fig. 130. Linen Fire Hose.

LINEN FIRE HOSE.

Hose to Withstand a Pressure of 300 Lbs. (Price per Ft.)

1-in.	1½-in.	2-in.	2½-in.	3-in.
$0.09	$0.13	$0.15	$0.17	$0.24

Hose to Withstand a Pressure of 400 Lbs. (Price per Ft.)

1-in.	1½-in.	2-in.	2½-in.	3-in.
$0.12	$0.15	$0.18	$0.21	$0.30

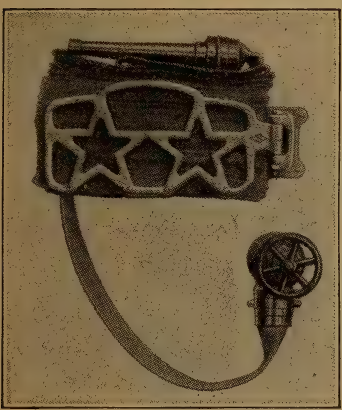

Fig. 131. Swinging Hose Rack.

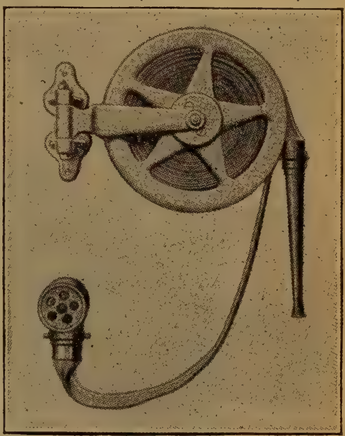

Fig. 132. Swinging Hose Reel.

HOSE RACK.
(Figs. 131 and 132.)

	Price.
Brass, size 7-8-9	$9,00
Iron, aluminum finish, 7-8-9	2.75
Malleable iron with wall plates, aluminum, gold bronze and Japanned, any color, size 7-8-9	4.70

FORGES

Small rivet forges, with pans 18" to 24" and blower fans about 12" in diameter, weigh from 110 to 130 lbs. and cost from $13.00 to $20.00. (Fig. 133.)

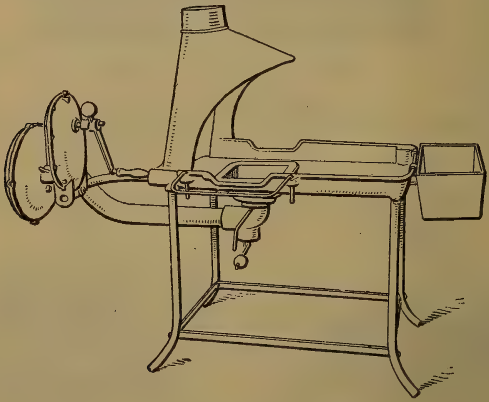

Fig. 133.

Larger forges, suitable for horse shoeing and small repair work, cost, complete, with water tank, as follows:

Kind of Blower	Size of Firepan (Ins.)	Weight (Lbs.)	Price
Hand blower	28x40	265	$ 27.00
Electric, with motor......	28x40	285	$60.00 to 75.00
Hand and electric	28x40	300	90.00 to 105.00

Without tank, less $4.00.

A first-class blacksmith forge for a permanent blacksmith shop, costs, complete, $125.00.

FORKS

Stone or Ballast Forks. Net prices for extra grades stone or ballast forks in quantities, at Chicago, are as follows:

No. Tines	Length Tines (Ins.)	Width Fork (Ins.)	Weight per Doz (Lbs.)	Price per Doz.
8	13½	11¼	76	$12.00
10	13½	14½	88	15.00
12	14½	13¾	96	17.40

The above prices are for forks with natural finish, wide strap ferrules and heavy caps, with wood "D" ash handles.

FORMS

Used for the assembling of column and girder forms. (Fig. 134.)

ADJUSTABLE STEEL FORM CLAMPS.

Clamp No.	Grip (Ins.)	Wt. 100 Pieces (Lbs.)	Price
22	22	592	$29.70
30	30	680	32.85
36	36	647	36.00
42	42	933	41.40

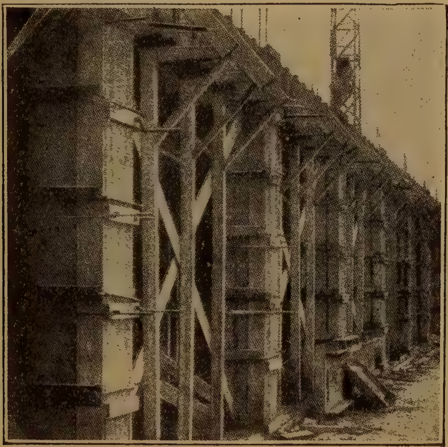

Fig. 134.

FURNACES AND KETTLES

A gasoline lead or leadite furnace (Fig. 135), having a melting pot capacity of 325 lbs. of lead or 50 lbs. of leadite, weighs, crated, 170 lbs., and costs $50.00.

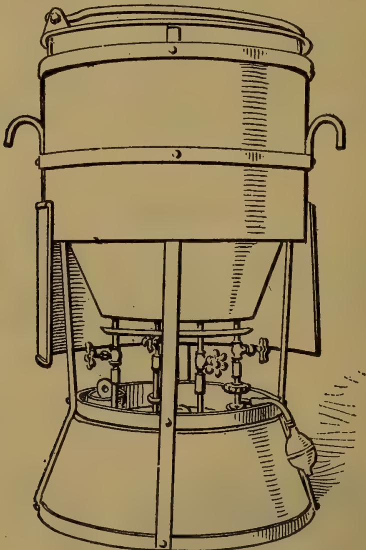

Fig. 135.

Fig. 136. Asphalt and Tar Kettles.

Asphalt and tar kettles (Fig. 136) of very heavy steel plate, reinforced with angle irons, for burning wood or coal, cost as follows:

Kettle, 38 ins. diameter, 21 ins. deep	$21.00
Mantle, 40 ins. diameter, 36 ins. deep	18.75
Mantle, with door and grate for burning coal	37.50

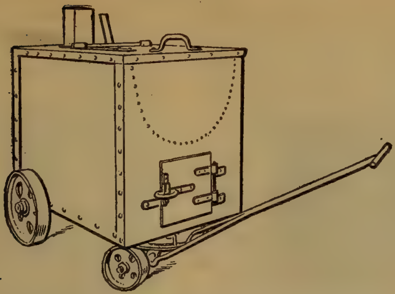

Fig. 137. Portable Asphalt and Tar Melting Furnace.

Asphalt or tar melting furnaces (Fig. 137) cost as follows:

Capacity (Gals.)	Price Not Mounted	Price Mounted
50	$42.50	$ 63.75
100	63.75	85.00
150	85.00	114.75
200		148.75
250		191.25

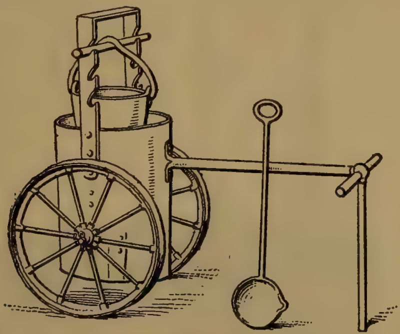

Fig. 138. Lead Melting Furnace.

Lead melting furnace (Fig. 138).

Price, including pot, bar, grate and ladle:

	On Wheels	On Legs
18-inch	$21.00	$16.25
24-inch	24.50	19.50
30-inch	31.50	24.40

Asphalt and tar kettle of 100 gallons capacity, mounted on wheels, complete, $135.00. (Fig. 139.)

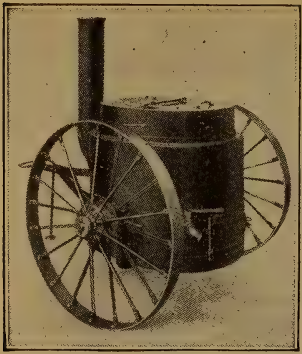

Fig. 139. Asphalt and Tar Kettle.

Fig. 141. Tar Furnace.

Standard fire wagon, mounted on wheels, length of body 5 feet 1½ inches, width 2 feet 6½ inches, depth 1 foot; complete, $95.00. (Fig. 140.)

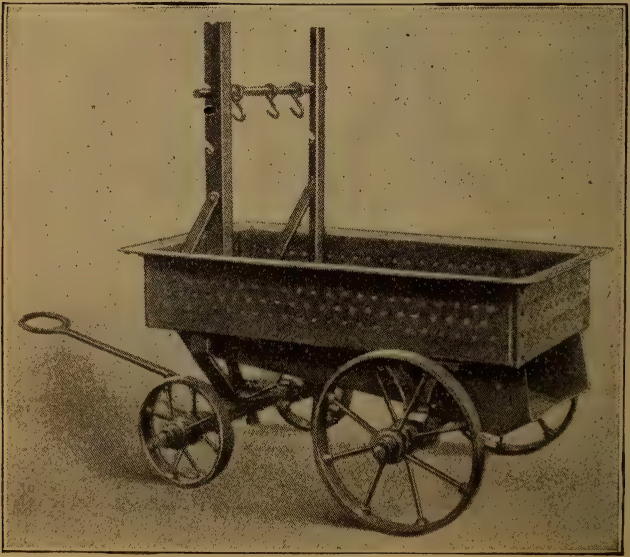

Fig. 140. Standard Fire Wagon.

GLASS

Skylight Glass. The prices range as follows:

Thickness (Ins.)	Price per Sq. Ft.
⅛	$0.07
3/16	.10
¼	.15

Wired skylight glass, ¼-in. thick, is $0.25 per sq. ft.

Vault Lights. Contractors furnishing their own moulds can obtain glass at from 4 to 5 cents per pound. Bull's eyes, 3 in. in diameter, are 3 cents each, and square lights, 3½x3½, are 5 to 6 cents each.

Plate Glass. On plate glass there is a discount of 89% from list. In the accompanying table the net price of polished plate glass is figured at this discount. These prices apply to the glass only, an extra charge being made for boxing or cutting to special sizes.

Window Glass. The discount from jobbers' list is 90% and 5%. This quotation is not strictly adhered to. The net prices per box of 50 sq. ft., at the discount named, are as follows:

AMERICAN WINDOW GLASS.

Size of Glass (Ins.)	A	B.
6x 8 to 10x15	$2.27	$2.16
12x14		
12x13 to 14x20	2.37	2.27
18x22		
20x20 to 20x30	2.70	2.50
15x36 to 24x36	2.80	2.55
26x28 to 24x36	2.95	2.65
26x34		
28x32 to 30x40	3.27	2.85
30x30		
32x38		
34x36 to 30x50	3.80	3.25
30x52 to 30x54	4.05	3.55

TABLE 122—NET PRICES OF POLISHED PLATE GLASS.

Length Feet	Width, Ft. 1	1.5	2	2.5	3	3.5	4	4.5	5	6	7	8	9	10
1	$0.24	$0.38	$ 0.50	$ 0.66	$ 0.86	$ 1.04	$ 1.18	$ 1.38	$ 1.52	$ 2.40	$ 2.86	$ 3.25	$ 3.75	$ 4.17
1.5	....	.59	.86	1.10	1.42	2.10	2.40	2.76	3.08	3.75	4.38	5.00	5.70	6.90
2	....	....	1.18	1.59	2.40	2.86	3.25	3.75	4.17	5.00	5.90	6.85	7.85	8.90
2.5	....	....	....	2.55	3.08	3.68	4.20	4.70	5.30	6.40	7.60	8.90	10.00	11.10
3	....	....	....	....	3.75	4.40	5.00	5.75	6.90	7.90	9.40	10.00	12.25	13.60
3.5	....	....	....	....	....	5.20	5.90	6.75	7.60	9.40	11.10	12.70	14.40	15.90
4	....	....	....	....	....	....	6.86	7.90	8.90	10.70	12.70	14.50	16.40	18.20
4.5	....	....	....	....	....	....	....	9.10	10.00	12.25	14.40	16.40	18.40	20.50
5	....	....	....	....	....	....	....	....	11.10	13.60	15.90	18.20	20.50	27.00
6	....	....	....	....	....	....	....	....	.....	18.20	19.00	21.80	25.00	27.80
7	....	....	....	....	....	....	....	....	.....	.....	22.20	26.00	29.40	32.50
8	....	....	....	....	....	....	....	....	.....	.....	.....	29.70	33.50	37.30
9	....	....	....	....	....	....	....	....	.....	.....	.....	.....	38.00	42.00
10	....	....	....	....	....	....	....	....	.....	.....	.....	.....	.....	47.50
11	4.60	7.20	9.80	12.50	15.00	17.50	20.00	22.60	26.00	30.60	36.20	41.20	47.20	65.00
12	5.00	7.90	10.70	13.60	16.40	19.00	21.80	25.00	28.00	33.50	39.30	44.80	63.50	70.80
13	5.50	8.70	11.80	14.80	17.75	20.80	24.10	27.20	30.10	36.40	43.50	61.50	69.00	112.50
14	5.90	9.40	12.70	15.90	19.00	22.25	26.00	30.20	32.50	39.40	46.70	66.00	109.00	146.30
15	....	....	.....	.....	.....	24.40	28.00	31.30	34.80	42.00	61.80	70.80	141.00	163.50
16	....	....	.....	.....	.....	33.00	37.80	42.50	47.20	55.50	66.00	109.00	157.00	202.00
17	....	....	.....	.....	.....	35.00	40.00	45.30	50.00	60.00	70.30	143.00	192.00	294.00
18	....	....	.....	.....	.....	38.00	42.50	47.80	53.20	63.50	109.00	157.00	280.00	311.00

GRADING MACHINES

(See also Elevating Graders.)

Machines which move earth by sliding or rolling over the ground and by either pushing the earth before them or into them by a combination of the two actions, thereby conveying the earth to the place of deposit, are known variously as scrapers, road machines, graders, spreaders, levelers, etc., and are of many types.

RAILROAD GRADER.

A machine mounted on standard gauge trucks, which spreads and grades the earth in railroad embankment work and is operated by compressed air taken from the train line, needs only one man to operate the machine itself. The theoretical capacity of the spreader is 179 20-yd. cars, or 3,580 cu. yds. in 13 minutes. It will make 17 yds. of heavy stone fill in one hour. The operating power required is a 17x24 locomotive, but a 20x23 is better. The machine weighs 6,500 lbs. and costs $3,000. Allowing $25.00 per day for the engine and crew and $3.00 for the machine crew, the cost of operation is $28.00 per day, or 16 cents per cubic yard for stone filling.

The commonly used scrapers are of three kinds: wheel, drag and buck or Fresno. In all three, as in the case of all scrapers and levelers, except where the soil is very sandy and loose, the earth must first be loosened by plows or picks. In the three kinds of scrapers the cutting edge of the machine digs into the soil, thereby loading itself, and the drag scraper slides over the ground carrying its load, the wheel scraper rolls along carrying its load and the Fresno scraper both drags, and carries and pushes a load in front of it.

Drag scrapers are efficient for a short distance only, from 50 to 100 feet, while Fresno scrapers can be used economically up to about 275 feet, when wheel scrapers should be substituted. The drag scraper is pulled by two horses and the driver dumps the scraper as well as drives. An extra man is usually needed for loading. In the case of the Fresno scraper, which is usually pulled by three or four horses, the driver is able to both load and dump the machine and to spread the earth to the proper depth while dumping it. The wheel scraper, however, needs a loader and an extra snatch team at the pit.

WHEEL SCRAPERS.

The sizes of wheelers most frequently used are Nos. 2, 2½ and 3, of which the ideal size for average work is No. 2½. The capacity of scrapers, as rated in the catalogues, can never be attained in actual work. the actual being about one-half.

List	Listed Capacity Cu. Ft.	Price	Weight, Lbs.
No. 1	9	25.50	330 to 400
No. 2	12	37.50	500 to 600
No. 3	16	$42.75	650 to 750

Add $6.00 to No. 2 and No. 3 for automatic tail gate, and add 10% for patent hubs and spring draft.

Repairs. Six new wheel scrapers: first cost, $45.00 to $50.00. Repairs for 6 months averaged $2.50 per scraper per month; life, 4 years. Second-hand wheel scrapers, original cost $45.00 to $50.00. Repairs, blacksmith at $3.50 per day over a period of 8 months, averaged $3.50 per scraper per month; life, 4 years. These scrapers were two or three years old when these data were collected.

DRAG SCRAPERS.

Drag scrapers likewise hold about half the listed contents.

TABLE 123.

Drag Scrapers.	Dimensions in Ins.	Gross Wt. in Lbs.	Net Wt. in Lbs.	Cubic Ft.	Listed Capacity, Cu. Ft.	Price F. O. B. Factory, Each
6 No. 1 American Scrapers, with runners	56x40x27	630	540	35	7	$3.60
6 No. 2 American Scrapers, with runners	56x36x26	567	480	30	5	3.30
6 No. 3 American Scrapers, with runners	54x34x24	535	450	25	3	3.10
6 No. 1 Imp. Cham. Scrapers, with runners	56x40x31	715	618	40	7	3.75
6 No. 2 Imp. Cham. Scrapers, with runners	56x37x30	630	540	35	5	3.45
6 No. 3 Imp. Cham. Scrapers, with runners	55x35x30	535	450	33	3	3.25
6 No. 1 Slusser Scrapers, with runners	54x27x41	635	540	35	7	3.60
6 No. 2 Slusser Scrapers, with runners	54x27x38	570	480	33	5	3.30
6 No. 3 Slusser Scrapers	53x26x35	537	450	27	3	3.10

American and Improved Champion Scrapers are of steel with round back.

Slusser Scrapers are of steel with square back

Four drag scrapers, originally costing $7.00, had a life of three years in good loam and others lasted but one year and a half in sand. In an average taken over four months of work, repairs to scrapers amounted to 20 cents per month each.

FRESNO SCRAPERS.

This type of scraper is ideal for building railroad embankments from side ditches and for wasting earth taken from cuts when the earth is free from large stones and roots. It has been the author's experience that if the scraper is pulled at right angles to the line of the plow furrows the loading will be com-

pleted in a much shorter time than when the scraper is pulled parallel with the furrows.

No. 1, 5-foot cutting edge, capacity 18 cu. ft., weight 300 lbs.	$14.00 to $18.00
No. 2, 4-foot cutting edge, capacity 14 cu. ft., weight 275 lbs.	13.50 to 17.50
No. 3, 3½-foot cutting edge, capacity 12 cu. ft., weight 250 lbs.	13.25 to 17.00

The listed capacity of the Fresno Scraper has been found by the author to be about twice the actual place measure capacity.

TONGUE SCRAPERS.

This machine is composed of a wooden platform drawn at an angle of about 60° with the surface of the ground and the horses are hooked to the pole. It is a very valuable machine for filling ditches, leveling roads or other uneven places. The author has found it an extremely economical machine for spreading top-soil which had been previously stacked in piles. It has a steel cutting edge 48 inches wide, which can be easily replaced. The weight is 120 lbs. and the price $6.15.

THE DOAN SCRAPER.

This machine is very useful for cleaning out and back filling ditches or leveling uneven surfaces. Manufacturers claim that it will back fill as much earth as 50 men with shovels. Price, $4.50.

Keystone Drag Scraper—Price, $12.00.

Happy Thought Road Scraper—Price, $15.00.

Beach All Steel Scraper for dragging dirt roads can be drawn at any angle. Price, $15.00.

GRADERS AND ROAD MACHINES.

The difference between graders and scrapers is that the scrapers pick up a load, transport it a certain distance and unload it at one place, while the road machine is used mainly for cutting off high places and filling up the adjacent low places while the machine is in motion. Another function of the grader is that of moving earth into winrows, or of spreading it from winrows in thin layers.

The following machines are drawn by two horses and operated by the driver alone:

20th Century Grader (Fig. 143) is a machine on two small steel wheels, with a 6-foot blade, which may be raised or lowered, tilted or set at any angle by the driver, who occupies a seat directly behind the wheels. This machine is very valuable for light road grading, crushed stone spreading and for any work that does not require the very heavy standard road machine. It weighs about 600 lbs. and costs $150.00 delivered anywhere in the United States.

The Little Yankee Grader (Fig. 146) is a machine weighing about 900 lbs., on four small wheels, with a blade 5½ feet wide. It is used for light grading and leveling and for spreading crushed

stone. Price, $135.00, complete with diggers and fenders; $125.00 without the diggers and fenders.

The Shuart Grader (Fig. 148) is a three-wheel machine, of a type similar to the Little Yankee Grader. It weighs 525 lbs. and costs $47.50.

Indiana Reversible Road Drag (Fig. 150). Price $15.00. Blade 7 ft. long.

Panama Road Drag (Fig. 151). Price $23.00, with lever for changing vertical angle of blade.

Humane Tongueless (Fig. 152). Price, $35.00, with lever for changing vertical angle of blade.

Panama Junior Reversible Leveler (Fig. 153). Price, $40.00. Adjustable for pitch and angle.

Panama Senior Reversible Leveler (Fig. 154). Price, $125.00. Adjustable for pitch and angle.

The following machines need one or more men besides the driver for operation:

The Steel Reversible Road Machine is made in two sizes. The standard size has a blade of direct draft and can be set at any angle and can be shifted 30 inches outside of the wheels. Price, $175.00. The small size weighs 1,400 lbs. and has a 6x15-inch blade. Price, $125.00.

The Buckeye Reversible Road Machine is made of steel, weighs 2,000 lbs. and costs $260.00.

The Reversible Steel Road Machine weighs 2,400 lbs., costs $175.00 and is drawn by two horses under ordinary conditions. The small size weighs, 1,400 lbs. and costs $125.00.

The American Champion Reversible Road Machine, designed for hard, rough work, weighs 2,000 lbs. and costs $210.00.

The Little Winner Reversible Road Grader is drawn by two horses and needs one operator besides the driver. It has a blade six feet long, weighs 1,500 lbs. and costs $125.00.

A Gravel Spreader was used in the construction of the Colorado River Levee. This spreader was built on an ordinary flat car and is of extremely simple construction. A small, well-braced tower is built in the center and on each side 8x17 in. pine stringers are firmly bolted to the side sills and to stringers laid across the top of the car body. Ten 1¼ in. eyebolts run up through these stringers and from these are suspended two isosceles triangular wings, one on each side of the car. These wings are raised and lowered by means of ropes and blocks at the point of the wings and at the top of the tower and are raised by braking the car and hauling on the line by a locomotive. On the outside the wings are faced with iron and have a reach of 15 feet. The 45-yard side-dump cars were unloaded when standing still, so that the top of the dumps on either side were from 3 to 4 feet above the tracks. In spreading this material the machine is put through the entire length at a speed from 7 to 10 miles per hour. Several trips with the wings at different heights are sometimes necessary. The cost of spreading material per yard is about 1/10 cent, the cost of constructing machine about $300.00, and its operation requires the service of a locomotive and of four men to handle the wings.

Fig. 142. No. 2½ Patent Wheeler.

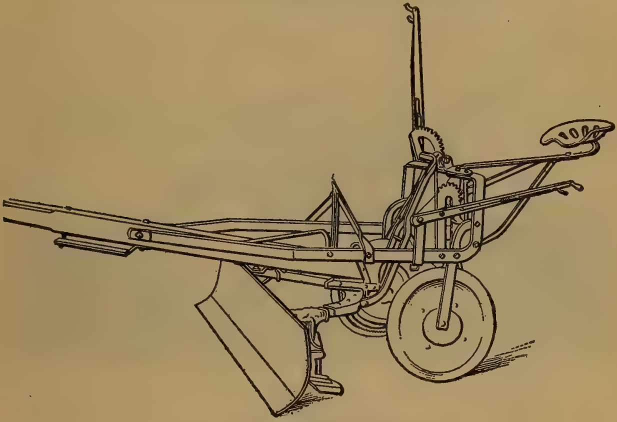

Fig. 143. 20th Century Grader.

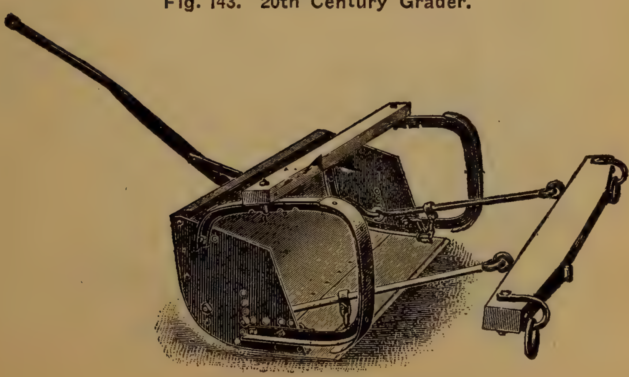

Fig. 144. Fresno Scraper.

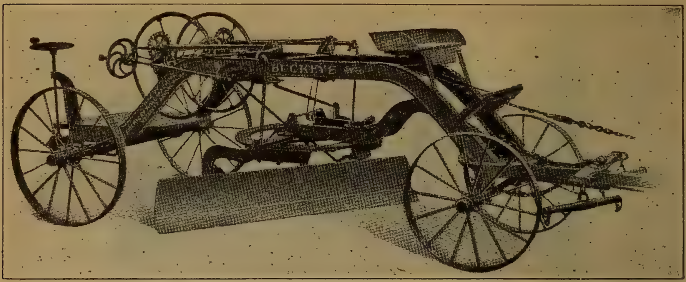

Fig. 145.

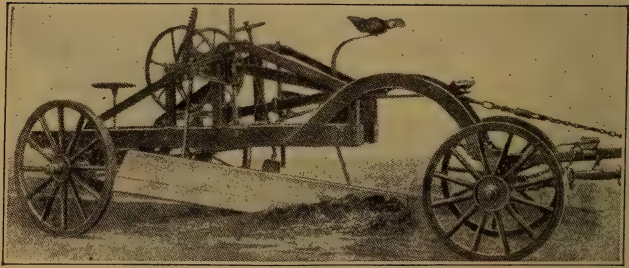

Fig. 146.

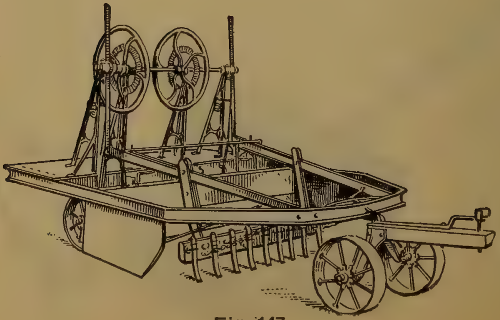

Fig. 147.

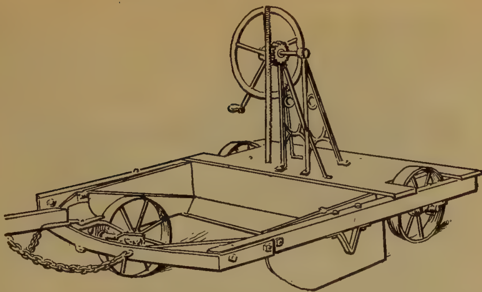

Fig 148. Shuart Grader.

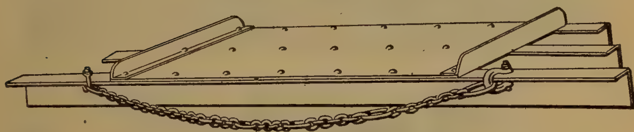

Fig. 149. Beach All Steel Drag.

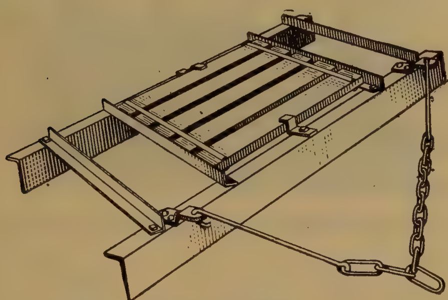

Fig. 150. Indiana Reversible Scraper.

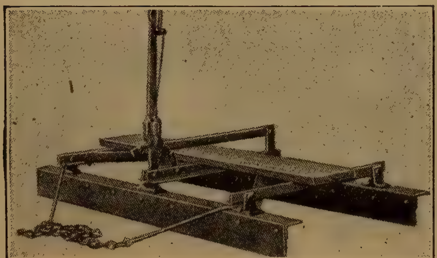

Fig. 151. Panama Road Drag.

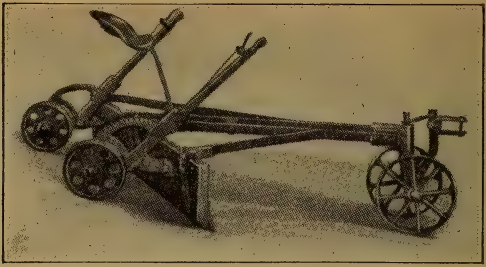

Fig. 152. Humane Tongueless Scraper.

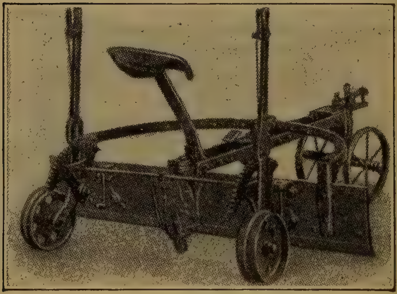

Fig. 153. Panama Junior Reversible Leveler.

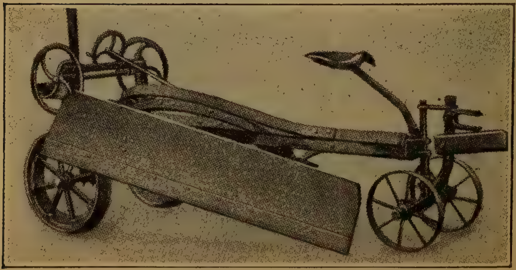

Fig. 154. Panama Senior Reversible Leveler.

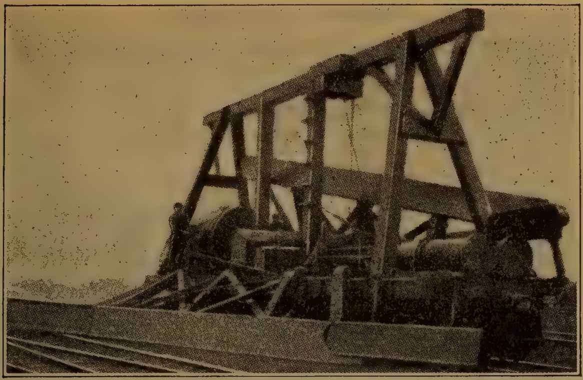

Fig. 155. McCann Spreader and Grader.

Fig. 156. All-Steel Slusser Scraper.

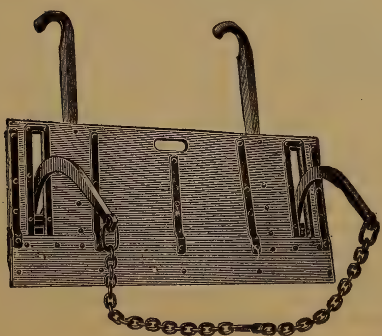

Fig. 157. Doan Scraper.

JORDAN SPREADER.

On the Hudson Division of the New York Central & Hudson River R. R., where considerable double tracking work was in progress, the Walsh-Kahl Construction Company were using a dump car train and Jordan spreaders (Fig. 158) to widen out shoulders sufficiently to lay a construction track so as to clear

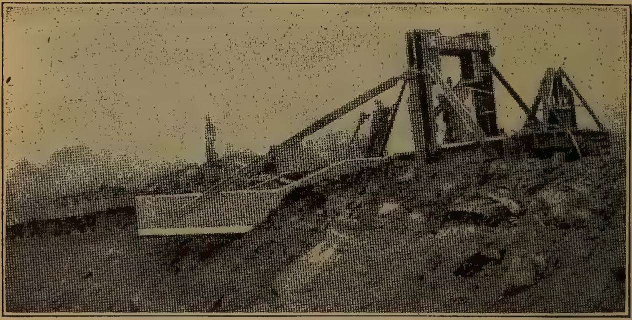

Fig. 158. Jordan Spreader in Use on Four Tracking.

the present main line tracks. With a good locomotive and crew a train load of 150 to 200 cu. yds. of ordinary material can be leveled so as to clear passing trains in 8 minutes and can be leveled down to 2 ft. below top of rail in from 10 to 15 minutes.

The cost per day of a spreader may be estimated as follows, assuming all items liberally to insure their covering the cost in any case:

Depreciation on $5,000 machine at 15 years life, 250 days per year	$1.33
Interest at 5 per cent	1.00
Repairs at $50 per year	.20
Labor, 1 operator	2.50
Oil, waste, etc	.10
Total	$5.13

This does not include cost of locomotive and crew.

This will indicate what may be the cost of using a spreader. If the machine is taken care of it should be sold at the end of 15 years for a reasonable price, but no account is taken of the scrap value in this estimate.

The machine can easily handle all material which can be supplied by trains which might be anywhere from 1,000 to 20,000 yards per day.

COST OF LEVELING GROUND WITH AN ELECTRIC DRAG SCRAPER.

By James C. Bennett.*

The gold-dredging industry of California has given rise to a method of leveling ground that offers possibility of a considerably more general application than has been developed to date. The method, by the electric drag scraper, was originated in the Oroville field, where one of the dredging companies was required by the municipality to restore to an approximately level surface the ground that it had dredged within the city limits. Although some such leveling had been done by means of horses and scrapers, prior to the development of the electric drag scraper, it had been on small tracts only, and the cost had been almost prohibitive when the acreage involved amounted to more than one or two, or possibily three, acres.

A few months ago, the writer was called upon to arrange for grading a piece of ground. The work involved leveling down some piles of gravel to a grade suitable for building lots, making a roadway 60 ft. wide by 600 ft. long, half the width being a cut and the remainder a fill, and filling a large water hole to a grade above the level of standing water. Practically all previous work had been done by owners on force account, and, since the only object to be gained was to level the ground to any convenient grade, no attempt had been made to determine the yardage involved, hence no unit cost was available. The nearest approach was based on the cost per acre, which ranged from $175 to $200 per acre. In this, however, it was impossible to secure any suggestion even as to the approximate yardage represented.

In preparation for the proposed work, an attempt was made to determine the approximate yardage involved by a rough measurement, but without success. Some idea may be gained of the difficulties of making measurements on ground of this character from the statement that, for purposes of railroad construction in this field, it was found necessary to make cross-sections at 10-ft. intervals. An estimate based on previous acreage costs would be unreliable in this instance, owing to the necessity of working to grade. The writer and the contractors made a joint estimate of the time required to do the work. As the approximate daily expense was known within fairly narrow limits, this afforded the most equitable basis of cost.

Seventy-five working days was agreed upon as sufficient time to complete the work. This was to include lost time on account of repairs, setting deadmen, moving lines and blocks, and moving machine from one position to another. During, and upon completion of the work, the following data were obtained:

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* Abstracted from *Engineering News*.

Daily Expenses

1 Winchman	$5.00	
2 Helpers @ $2.50	5.00	
1 Horse (for moving lines, etc.)	1.00	
133.33 kw-hr. @ 2¼ cents	3.00	
Making a total daily cost of		$14.00

Time Required

No. days actually scraping	62	
No. days moving lines and winch and making repairs	10	
Making total days worked		72
No. working days in which no work was done	10	
Making elapsed working time days		82

Costs

72 days @ $14.00	$1,008.00	
Repairs, materials only	35.00	
4-horse team, man and scraper, surfacing street grade, 1 day	10.00	
600 ft. second hand, 1¼-in. hauling line	54.00	
600 ft. second hand, ⅞-in. back line	30.00	
Depreciation at 10 per cent	120.00	
Making a total cost of		$1,257.00

In the foregoing figures, as will be noticed, a charge is made against the job for the full cost of the ropes. In doing this, the job is being charged with a little more than is really legitimate, as the same ropes are good for probably two to three thousand yards additional. Also, the depreciation charge is probably liberal, as there is very little severe wear and tear on anything but the scraper.

A close tally was kept of the number of trips made, or loads hauled, and, from time to time, the loads were measured. An average of 1¼ cu. yd. per trip is believed to be very nearly correct. The total amount of material moved, based on the number of trips made, was 15,300 cu. yds. The actual cost per cubic yard was thus 8.2 cents.

For the 62 days of actual scraping, the average running time was seven hours per day.

Average length of haul	175 ft.
Average day's duty	247 cu. yds.
Largest day's duty	425 cu. yds.
Average hourly duty	35.2 cu. yds.

The equipment consisted of a winch, motor, transformers, drag scraper, hauling and back lines, and snatch blocks. The winch was of the type commonly used on gold dredges, having been taken from a dismantled dredge. It was driven by a 50-h. p. motor, through one belt and two gear reductions, giving a rope speed—both lines—of about 130 ft. per minute. There was but one drum on the winch, having a central flange to separate the ropes. The hauling speed proved a very satisfactory one, but the return rope should have been speeded up to at least 150 ft., and possibly would have worked satisfactorily at 175 ft. per minute.

In fitting up the winch for the scraping work, the original cast-iron frame was discarded in favor of a much lighter timber frame, in which skids were made a part of the machine. For transmitting power from the transformers to the motor, an armored three-conductor cable was used. This permitted the winch to be moved about the field with its own power, and made unnecessary any moving of transformers. During the execution of the work, the winch was moved twice, that is, had three positions, including the original.

The transformers were not disturbed after being originally connected, as the nature of the ground permitted the selection of a location within reach of the several positions of the winch. The power company made no extra charge for running the necessary pole line—some five or six hundred feet—and connecting the transformers and motor.

The scraper was made of 2-in. planks, the cross-section being of the shape shown by the accompanying sketch (Fig. 159). The

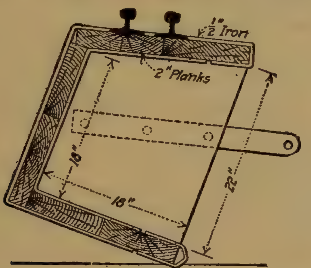


Fig. 159. Section Through Bucket Used on Electric Drag Scraper.

inside measurements were 18x18 in. and it was 12 ft. wide. A little experimenting was necessary at the beginning of the work to determine the correct angle at which the bail irons should be set. It was found necessary to make one or two changes of this angle during the progress of the work, owing to different conditions of ground and material. The planks were well strapped together with bar steel, and the ends were of steel plate. One, and some of the time two, pieces of rail were fastened to the top of the scraper for added weight. Both hauling and back lines were second-hand mine hoist ropes, in very good condition, but discarded for mine use in compliance with state mining laws. With the exception of one or two small portions of the work, the hauling line ran over only one snatch block, while the back line ran over three blocks a large portion of the time. A fairly liberal use was made of deadmen, it being more economical than to move the winch.

HANDLES

Shovel Handles. Net prices at Chicago for white ash "D" shovel, spade and scoop handles are as follows:

	Per Doz.
Shovel, bent and riveted	$2.55
Spade, bent and riveted	2.46
Scoop, bent and riveted	2.55
Ditching spade, bent and riveted	3.00
Shovel or spade, straight, riveted	2.46
Shovel, straight, Maynard pattern	2.46

The net prices for long shovel, spade and scoop handles are as follows:

	Per Doz.
4½-ft., shovel, bent	$2.40
4½-ft., spade, bent	2.10
4½-ft., scoop, bent	2.40
4½-ft., shovel, straight, Maynard pattern	2.10

Malleable "D" with wood head and malleable fork and socket can be bought for $1.00 per dozen. Malleable "D's" with iron head cost $1.25 per dozen.

Tool Handles. Net prices at Chicago for tool handles in full crate quantities are as follows:

	Per Doz.
Nail hammer, adze eye, 14-in	$0.45
Riveting hammer, 12-in	.40
Riveting hammer, 14-in	.40
Blacksmith, 18-in	.50
Blacksmith, 20-in	.60
Hatchet, regular, 14-in	.45
Hatchet, broad, 18-in	.60

The above are for second growth hickory with wax finish, clear and white, and free from all imperfections. They are packed 5 dozen to the case. The net prices for hickory axe handles, both single bitted and double bitted, 36 in. long, are $2.45 per dozen for extra grade and $1.25 for No. 1 grade. Railroad pick handles, 36 in. long, can be bought at $2.88 per dozen for extra grade second growth hickory, at $2 for second growth ash, and at $1.50 for second growth hickory, plain finish. The net prices for sledge, tool and maul handles are as follows:

	Price per Dozen	
Length, Ins.	Extra Grade	No. 1 Grade
24	$1.00	$0.70
28	1.25	.80
30	1.40	.95
36	1.70	1.15

Grub hoe handles, 36 in. long. of second growth hickory, with wax finish, can be bought for $2.90 per dozen. Adze handles can be bought for $2.52 per dozen.

Cross-Cut Saw Handles. Supplementary for one man saw, $1.00 per dozen.

One man	$1.85 per doz.
End handles	6 to 25 cents per pair

HARROWS

A light gardener's tooth harrow, with runners on the upper side, costs:

With 25 teeth	$6.00
With 30 teeth	6.50

A common square harrow of simple but strong construction costs:

With 15 teeth, for one horse	$6.00
With 19 teeth, for one horse, heavy	6.25
With 23 teeth, for two horses	7.00

A hinge harrow with runners on the reverse side, made in two sections hinged together, has 40 teeth and costs $9.50.

A steel disc smoothing harrow, with a frame 6 ft. 8 in. by 6 ft., has 4 sets of rollers and 58 discs, 8 in. in diameter. Price, $17.00.

A flexible disc or cutaway harrow of steel, regulated from the driver's seat, costs as follows:

Two horse, with twelve 12 to 16-inch discs, 6 feet wide	$20.00
Whiffle trees and neck yoke	1.50

A tooth harrow, original cost $25.00, averaged for repairs for 3 months, $1.30 per month. Cultivators, which cost $12.00 to $15.00 when new, averaged $1.05 per month for repairs during 3 months.

HEATERS

A heater consists of a steel framework (Fig. 160) the sides of which are built up of perforated shelves arranged so that the

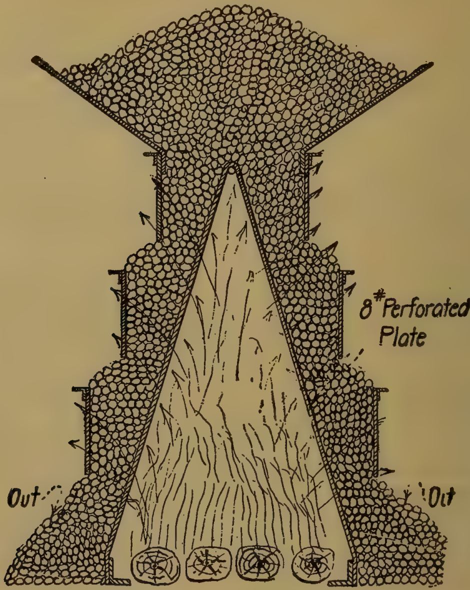


Fig. 160. A Portable Gravel and Sand Heater.

gravel or stone drops from one shelf to another and is heated by a fire built beneath. It will dry gravel or stone up to 2 in. in size, but cannot be used for drying sand.

No.	Cost	Capacity Tons per Hour	Weight Lbs.	Delivered
1	$250	6	1,600	At once
2	225	5	1,240	10 days
3	200	4	1,035	10 days
4	175	3	775	10 days

A portable heater for warming stone for bituminous surfacing of highways (Fig. 161), which may be had arranged with a self-contained batch mixer and binder melting tank, consists of a revolving steel cylinder with concentric walls, engine and an oil heater with compressor for vaporizing the fuel, all mounted on heavy steel trucks. This machine has a capacity of 150 cu. yds. per day, heating stone to 250° F. It can be heated by coal, but this is not recommended. It consumes 1 gallon of oil or 10 lbs. of coal per hour. Weight with engine, 22,600 lbs.; price, $3,000; weight, without engine, 20,000 lbs.; price, $2,500. Equipped with mixer and heating tank for bitumen, $1,000 extra.

This machine may also be obtained in the large, semi-portable type for $2,850, without engine or mixer.

A combination sand, stone and water heater is herewith illustrated (Fig. 161A). It was used to heat the materials used in constructing concrete culverts on the New York Central & Hudson River R. R. It consists of a semi-cylindrical sheet of steel 10 ft. long and 2 ft. high. One end of the arch is closed

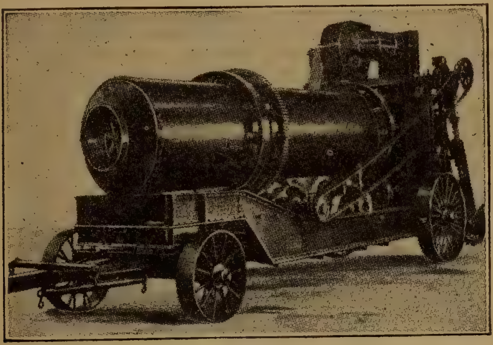


Fig. 161.

and a short smokestack is erected on top. On the other end a water tank having a capacity of 97 gallons and with a radiation of 12 square feet is constructed. A wood fire is built under the work and the sand and gravel to be heated are heaped on the top and sides. It weighs 1,200 lbs. and can be built for about $50.00.

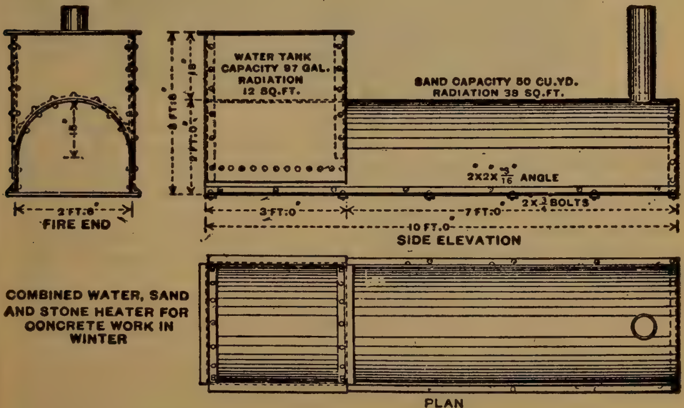


Fig. 161A. Combined Water, Sand and Stone Heater for Concrete Work in Winter.

HODS

Mortar and Brick Hods. The net prices for wooden mortar and brick hods in quantities at Chicago are as follows: Mortar hods, carrying 150 lbs., 80 to 90 cents each, or $8 to $9 per dozen; wooden brick hods, carrying 90 lbs.: 60 to 70 cents each, or $6 to $7 per dozen. The hods have tin lined shoulder blocks and rough hickory handles. Steel mortar and brick hods can be bought at the following net prices at Chicago: Brick hods, 23x7x10 in., weighing, with handle, about 8 lbs., $1 each, or $10 per dozen; mortar hods, 24x11¾x12 in., weighing, with handle, about 11 lbs., $1.20 each, or $12 per dozen.

HOES

The net prices at Chicago for garden or field hoes, forged from the best hoe steel, with 4½-ft. selected white ash handles and 7½-in. blade, are $4.35 per doz. for hoes with solid socket and $3.90 per doz. for hoes with solid shank. Grub hoes, adze eye, can be bought at the following net prices:

No.	Weight, Lbs.	Size, Ins.	Price, Each	Price per Doz.
1	3½	3¾x10¾	$0.295	$2.95
2	3	4 x11¼	.31	3.10
3	4½	4¼x11½	.315	3.15

GARDEN OR FIELD HOES.

Contractors' special caisson grub hoes, heavy pattern, 5 lbs. weight, 4¼x11½-in., can be bought at the net price of 60 cts. each, or $6 per doz.; an extra heavy pattern for hard pan, 8 lbs. in weight and 3x12 ins. in size, can be bought at the net price of $1.50 each, or $15 per doz.

Mortar Hoes. The following are net prices at Chicago for mortar hoes forged from best hoe steel, with 6 ft. selected white ash handles and solid shanks.

Mortar hoes, weighing 45 lbs. per dozen, 55 cts. each or $5.75 per dozen; mortar mixing hoes with two holes, 60 cts. each or $6.25 per dozen.

Stone Hooks. Hop or stone hooks in quantities can be bought at Chicago at the following net prices: 4-tined, diamond backed, extra heavy hook, 5 ft. handle, at $9 per dozen; 4-tined diamond backed, light hook, 4½ ft. handles, at $5.80 to $6.80 per dozen.

HOISTS

Material elevators constructed so that one platform is moving up at the same time that the other is moving down are built of wood reinforced with iron. The price includes all the necessary sheaves and ⅜-in. 6x19 crucible steel rope.

Length of Guides (Ft.)	Weight in Lbs.		Price	
	With Guides	Without Guides	With Guides	Without Guides
80	2,200	1,200	$140.00	$100.00
95	2,400	1,200	150.00	105.00
110	2,600	1,200	160.00	107.00
120	2,700	1,200	170.00	110.00
135	2,800	1,200	175.00	115.00
150	3,000	1,200	180.00	120.00

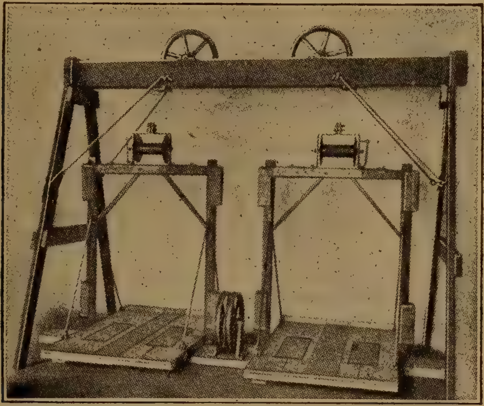


Fig. 162.

The sizes, prices, etc., below are those of a bucket, rope, sheaves, etc., but do not include the engine.

Size	Capacity, Cu. Ft.	Weight, Lbs.	Price
1	10	500	$ 70.00
2	20	750	75.00
3	30	1,000	100.00
4	40	1,250	125.00

The following prices are those of a hoist which was used to deliver concrete in a ½-cu. yd. bucket 175 ft. above the mixer. The round trip was made in 35 seconds, 160 cu. yds. were actually raised in 10 hours, using a hoisting engine having a speed of 300 ft. per minute.

Bucket, 300 ft. of rope and friction clamps	$150.00
Tower to 197 ft. high complete	450.00
Steam winch, new	650.00

The following prices are those of a hoist complete, including gasoline engine, winch and all fittings.

Capacity, Lbs.	Engine H. P.	Speed	Price
600	2½	100 to 150 ft. per minute	$275.00
1,500	4		325.00
2,000	5		335.00

A contractor's or builder's portable material elevator furnished with an overhead horse made of strong pine supporting the upper sheaves, and strongly braced and having two cages with ash platforms 4x6 ft. in size, costs complete with the necessary ⅜-in. rope for the four wire guides and ½-in. hoisting rope as follows:

50-ft. Guides	$100.00
75-ft. Guides	140.00
80-ft. Guides	145.00
90-ft. Guides	150.00
100-ft. Guides	155.00
120-ft. Guides	175.00

A builder's hand power, double acting hand elevator with a capacity to a height of four stories of 20,000 to 30,000 brick in ten hours. Space required, 3 ft. 6 ins. x 6 ft. 3 ins. Each cage carries 2 hods. Price complete with overhead horse and sheave, winch, 2 cages, lower sheaves, rope for hoisting and guides, 10 brick hods and 5 mortar hods, $180.00.

The labor cost of unloading and building an elevator tower 50 or 60 ft. high, and placing in condition ready for work, is about $50 or $60, with an extra charge of about $1 for each additional foot in height.

AUTOMATIC CONCRETE ROLLER HOIST.

This concrete elevator is carried under the mixer at the bottom and dumped into a hopper at the top, these movements being positive and automatic. The bucket is controlled by steel guide angles bolted to top and bottom ends of vertical wooden guides, whose direction controls the position of the bucket when being filled or dumped. The tower is constructed of wood throughout. Complete equipment includes bucket, wire rope sheave in bucket bail, and set of 5 angle guides.

Capacity Cu. Ft.	Weight Lbs.	Wire Rope Required	H. P. at 60 Ft. per Min.	Price
12	445	½-in.	9	$60.30
18	530	⅝-in.	12	63.00
27	665	⅝-in.	18	81.00
36	975	¾-in.	24	90.00

COMBINATION HOIST.

This is a platform elevator with a detachable automatic concrete bucket. With the bucket removed the frame is large enough to carry wheelbarrows or carts. Complete equipment includes elevator frame and bucket assembled with wire rope sheave in bail of frame. Wooden guides control the dumping of the bucket.

Capacity Cu. Ft.	Weight Lbs.	Wire Rope Required	H. P. at 60 Ft. per Min.	Price
12	640	½-in.	9	$64.80
18	750	⅝-in.	12	67.50
27	1,000	⅝-in.	18	85.50
36	1,150	¾-in.	24	99.00

Hoisting frame only, $34.50, weight 435 lbs.

RECEIVING HOPPERS.

These hoppers are economic when the lead from the elevator to the dump is great, as the elevator is not delayed thereby. They are easily set in place.

Dimensions and prices of hoppers with gate:

Capacity, Cu. Ft.	Weight, Lbs.	Gate Opening	Price
24	425	12x8 in.	$58.50
30	465	12x8 in.	63.00
40	635	12x8 in.	72.00
54	725	12x8 in.	85.50

Hopper gate only $11.70; weight 55 lbs.

STANDARD SHEAVE SETS.

For use particularly in connection with the foregoing concrete hoists.

DIMENSIONS—OVERHEAD SHEAVE SET.

Diam. of Sheave (Ins.)	Diam. of Shaft (Ins.)	Weight per Set (Lbs.)	Size Wire Cable	Price
12	$1\frac{3}{16}$	50	⅝-in.	$8.10
14	$1\frac{5}{16}$	65	¾-in.	9.90

DIMENSIONS—BOTTOM SHEAVE SET.

Diam. of Sheave (Ins.)	Diam. of Shaft (Ins.)	Weight per Set (Lbs.)	Size Wire Cable	Price
12	1	36	⅝-in.	$3.60
14	1¼	42	¾-in.	4.50

CONCRETE CHUTES.

The concrete is usually elevated by hoist to a hopper placed at the proper height to give sufficient fall or head to the line, the chute leading off from this hopper by the special "Hopper End

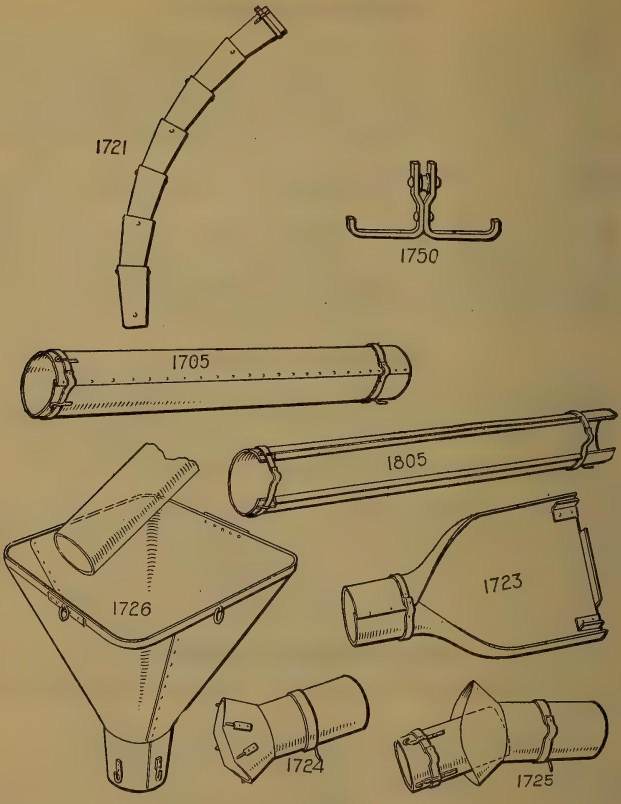


Fig. 163.

Item No.	Item	Length	Wt. per pc. (Lbs.)	Price
1703	Closed Chute	3′	30	$1.80
1705	Closed Chute	5′	45	2.70
1710	Closed Chute	10′	83	4.95
1805	Open Chute	5′	50	2.70
1810	Open Chute	10′	97	4.95
1721	Flexible Chute	12′ 6″	125	9.90
1722	Extra Flexible Joints............	1′ 9″	17	1.44
1723	Hopper End Section	2′ 6″	40	2.70
1724	Turning Section..................	1′ 5″	22	2.00
1725	Swivel Section	2′	33	4.50
1726	Remixer	2′ 6″	67	6.75
1750	Chute Hooks		1	.15

Spouting made of No. 14 blue annealed steel plate. Allow 6 ins. for each joint.

Section" attached to the hopper gate. The joints are made by inserting the end of one chute into the end of another with three chains on one chute and three corresponding hooks on the other. The diameters of the chutes are: Open, 7¾ ins.; closed, 8¾ ins. The bail of the chute is hung over "Chute Hooks" tied to the ends of small ropes running through blocks fastened to a cable at distances corresponding to the length of chute to be used. This makes easy the adjusting of the slope of the chute, and relieves the joint of all strain. The "Turning Section" and "Swivel Section" are used for sharp turns or feeding dependent lines. The concrete is spread by the "Flexible Chute Section" the upper end of which is attached to a "Swivel Section." If found desirable, the concrete is dropped from the end of the line through the "Remixer," where the throwing of the concrete against the side of the box sets up a rotary movement in, and ensuing remixing of the mass. This box may also be used as a head chute to receive the concrete direct from the mixer when the work is below grade.

The inclination of the chute at the hopper should be about 45°. The subsequent grade is determined by the consistency of the mixture, the head available and the necessities of the work. The minimum grade should be about 25°, average 35°, and maximum 50°. With the closed chute a better head can be maintained.

HOISTING TOWERS

A wooden tower was used for placing the concrete in a grand stand built at the University of Chicago. The grand stand was 484 ft. long by 114 ft. wide, and it was necessary to move the tower four times in order to place all the concrete. The tower was 72 ft. high and 8x8 ft. in section (See Fig. 164). A ¾

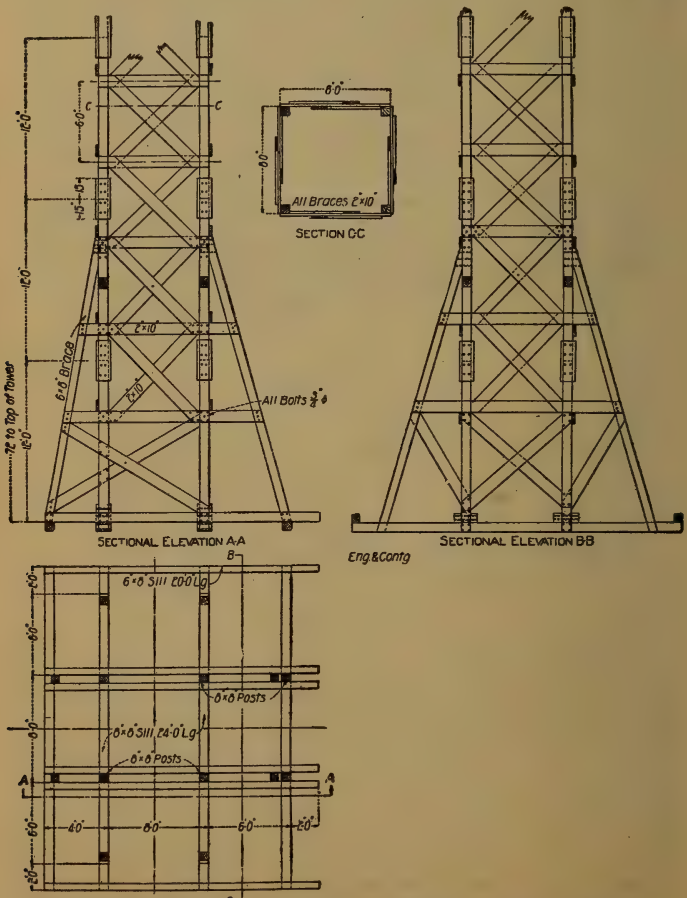


Fig. 164. Movable Wooden Tower for Concrete Chuting System.

cu. yd. mixer was set on the bottom framework of the tower so that it would discharge into a bucket, which in turn elevated the concrete to a hopper on the side of the tower, 60 ft. above. The chutes were of the open-trough type, 10x12 ins. in size, of galvanized iron, and were suspended from cables run from the tower over the grand stand. The tower was placed on 6-in. wooden rollers placed on a plank runway, power for moving being supplied by a cable from the hoisting engine. Six men were required to place rollers, runway and cables while moving. A move of 50 ft. occupied about 4 hours. The cost of the tower, including labor and material for erection and labor for dismantling was about $600.

COMPARISON BETWEEN TOWERS OF STEEL AND WOOD.

The cost of a wooden tower is about $600. If we figure that it will be good for only one job, that job must be large enough to warrant the expenditure of $600 to avoid using the ordinary wheelbarrow method. The difference in cost of placing concrete by the two methods is usually about 75 cts. per cu. yard of concrete so that if we have a job containing more than 800 cu. yds., or say 1,000 cu. yds., the chuting system will be the more economical. If the tower is built carefully and so that it may again be erected on other work it will pay to build one for smaller jobs. It will cost about $200, however, to erect such a tower on any job, so that on a job containing less than 200 cu. yds. it would not be practicable to use a tower, especially a tower of such size.

There will be no difference in the cost of concreting as between wooden and steel towers, as their operation is practically the same. The difference in first cost is the main consideration and for towers 75 ft. high this is about $400. The wooden tower can not, however, be expected to maintain its rigidity for more than a half dozen jobs and there is no doubt that if a permanent tower is desired, a steel tower will be more economical than a wooden tower after five or six jobs have been built. This is very well illustrated by comparing the cost of setting up. Assuming that the cost of the erection of the wooden tower is $200 and the cost of erecting the steel tower is $100, we have added $800 to the original cost of the wooden tower by the time it has been erected for its fifth job. The money invested in it then is $600+ $800 or $1,400. By the time the steel tower is erected for its fifth job the money invested in it is $1,000 + $400 or $1,400, an equal amount to that invested in a wooden tower. The wooden tower may still be in fair condition but it is reasonable to believe that the steel tower will remain in good condition for a much longer time and it will cost only about half as much to erect. We may assume, therefore, that a portable wooden tower is economical for jobs above 1,000 cu. yds. and until it has been erected five times, and that a portable steel tower would be more economical if its use is contemplated for more than five jobs.

The first towers used for hoisting concrete were naturally of wood and were located entirely within an area to which chutes could be run in all directions. Later, auxiliary towers were used in connection with very high main towers to carry concrete to a considerable distance, this distance always being controlled by the

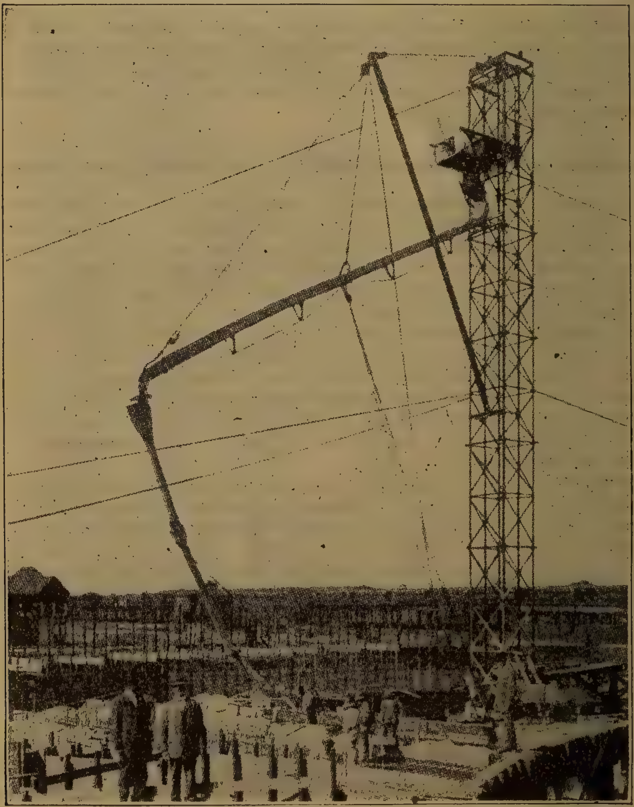


Fig. 165. View of Concreting Tower.

angle of the chute (about 23° to 30°), and the height of the main tower. The steel tower was primarily substituted for the wood tower to provide a permanent "knock down" structure which could be used over and over. Its rigidity as compared with the wooden tower has finally led to the portable feature. This feature makes

the steel tower more economical than wooden towers as auxiliary towers and also makes the steel tower more economical than a fixed wooden main tower under the conditions illustrated in Fig. 165, which pictures the construction of a thirty-stall concrete roundhouse for the Lake Shore & Michigan Southern Railway, and is described in *Engineering and Contracting*, August 2, 1912. Here, it was at first planned to build three wood towers for the construction of this roundhouse, which is 405 ft. in diameter. These were estimated to cost at least $2,200, as against $1,000 for a single steel tower, which could be moved from place to place.

Other towers built for this purpose will no doubt be improved, as the experience with this one has shown to be advisable. A swivel post should be placed at the top to fasten the guys, so that the tower may be turned around more easily, and probably some sort of truck placed underneath would facilitate the shifting of the tower.

Figure 165 shows the construction of the tower which is 72 ft. high. The steel work is carried on wooden skids which lie across two railway rails forming a truck. On the bottoms of the skids, where they rest on the rails, are steel plate shoes which are fitted with clamp butts for anchoring the tower to the rails. The tower is also guyed, the guys running through blocks at the deadmen.

Referring to Fig. 165, it will be seen that attached to the tower is a main spout 60 ft. long consisting of a U-shaped trough 10 ins. across at the top and 10 ins. deep, made of galvanized sheet iron. This trough is open, except at its lower end, where it discharges into the 30-ft. swivel pipe leading to the forms. The concrete can be spouted 95 ft. with this arrangement of 110 ft. with an extension pipe, which is kept at hand. This trough is supported by a light steel truss, which is shown in the photograph. A special feature is the support of this spout and truss by a 40-ft. boom which is rigged from the top of the tower and held in place by a steel cable running to a winch placed at the foot of the tower. The construction of the trough on top of the truss is such that the wearing parts may be easily removed and replaced without disturbing the truss itself.

A PORTABLE PLANT FOR MIXING AND CONVEYING CONCRETE FOR FOUNDATION WORK; LABOR COSTS OF 36,000 CU. YDS. OF WORK.*

The accompanying photograph (Fig. 166) illustrates a portable concrete mixing and conveying plant which was used by the Great Lakes Dredge & Docks Co. on foundation work for a blast furnace plant near Chicago. The concrete plant is built on a platform 20 ft. square which is mounted on rollers. On the platform

* Data taken from a table appended to paper by Victor Windett, presented to Western Society of Engineers on June 7, 1911, published in *Engineering and Contracting* July 5, 1911.

a 75 h. p. horizontal boiler is mounted which furnishes steam for the operation of the Ransome mixer and Lidgerwood hoist. The 1-yd. mixer is placed near the rear of the platform and a hopper bin is erected above it, which has a capacity of 10 cu. yds. of stone and 5 cu. yds. of sand. The bins were filled from cars on a parallel track, by means of a locomotive crane and clamshell

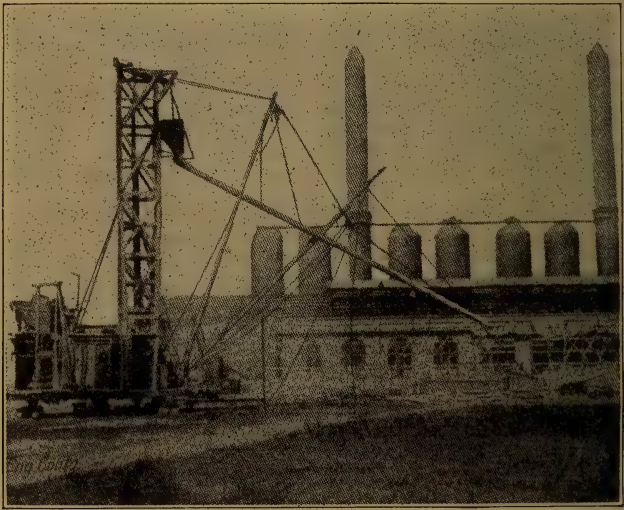


Fig. 166. View of Portable Mixer and Conveyor Used for Massive Foundation Work.

bucket. Storage is provided for 500 bags of cement on the platform at one side of the mixer. The material from the storage bins is dumped into a 1-yd. batch hopper. From the mixer the concrete is delivered to a Ransome tower bucket which is raised 75 ft. and delivered into the chute. The chute consists of a 12-in. galvanized pipe, supported by two 80-ft. booms. From the ends of the booms lines run to equidistant points on the chute thus supporting it uniformly and keeping it in a straight line. The booms are swung horizontally over the work by hand. The lower 60 ft. of pipe is made in movable lengths of 8 ft. The plant itself is pulled along on its rollers by attaching a line to a deadman and taking it in on the hoist.

The concrete work consisted of foundations for power house and blast furnace buildings. The work was started in 1910 and continued through the winter and spring of 1911.

The work on the blast furnace building was massive concrete

work, the blast furnace foundations consisting of concrete slabs 50x70 ft. square, and having a firebrick core averaging 23 ft. in diameter. There were 10,809 cu. yds. of concrete placed at a complete labor cost as given below:

Sq. ft. forms per cu. yd.		7.57
Sq. ft. footing surface (no forms)		8.54
Total days work		110
Actual concreting time, days		88
Labor days of 9 hours		5,020
Concrete placed per day of concreting days (yds.)		123
Concrete placed per day of total time (yds.)		98.5
Labor cost per cu. yd. per day per man	$	0.46
Total cost per cu. yd.	$	1.43

Fig. 167.

The work on the hot blast stove and boiler foundations was massive work, including 10,064 cu. yds. of concrete placed during the summer at the following cost:

Sq. ft. form surface, per cu. yd.		9.74
Sq. ft. surface without forms, per cu. yd.		16.1
Total days work		79
Total days concreting		57
Total labor days of 9 hours		3,977
Concrete per day of total time (yds.)		128
Concrete placed per day of concreting time (yds.)		172
Cost per cu. yd. per man, per day	$	0.40
Total labor cost per yd.	$	1.24

This work was done in the winter. The power house foundations consisting of light piers, floors and some massive piers, including in all some 3,733 cu. yds., were placed as follows:

Sq. ft. form surface per cu. yd.	12.8
Sq. ft. surface without forms, per cu. yd.	14.4
Total days work	75
Total days concreting	36
Total labor days of 9 hours	2,310
Yds. concrete per day of total time	49.6
Yds. concrete per day of concreting time	103.5
Cost per cu. yd. per man per day	$ 0.62
Total cost per cu. yd.	$ 2.02

The casting machine building foundations were built in the spring. These consisted of light piers and walls amounting in all to 1,225 cu. yds. This concrete contained no reinforcement.

Sq. ft. form surface per yd.	14.2
Sq. ft. surface without forms	....
Total days work	17
Total days concreting	14
Total labor days of 9 hours	922
Yds. concrete per day of total time	72
Yds. concrete per day of concreting time	87.5
Cost per cu. yd. per man per day	$0.75
Total cost per cu. yd.	$2.32

The work on the wharf consisted of 3,344 cu. yds. of concrete in massive work. Two rows of piles were capped with concrete forming a base for the walls supporting the rails of the unloading crane. This work was done in the winter and early spring. The data on the work are as follows:

Sq. ft. form surface per cu. yd.	6.1
Sq. ft. surface without forms, per cu yd.	.....
Total days worked	24
Total days concreting	20
Total labor days	1,290
Yds. of concrete per day of total time	139
Yds. of concrete per day of concreting time	167.5
Cost per yd. per day per man	$ 0.39
Total cost per yd.	$ 1.21

The construction of the piers for the steel trestle consisted of moderately heavy work amounting in all to 6,971 cu. yds. of concrete. The work was done in the winter and the chuting system was not used. Instead the concrete was delivered in hand pushed Koppel cars of 1 cu. yd. capacity.

Sq. ft. form surface per cu. yd.	8.69
Sq. ft. surface without forms, per cu. yd.	14.7
Total days worked	70
Total days concreting	62
Total labor days	3,900
Yds. concrete per day of total time	100
Yds. of concrete per day of concreting time	113
Cost per yd. per day per man	$ 0.56
Total cost per cu. yd.	$ 1.74

The general averages and totals taken from the above data furnish the following:

Total yds. concrete placed	36,146
Sq. ft. forms per cu. yd.	9.0
Sq. ft. concrete surface without forms (per yd.)	13.0

Total days worked		375
Total days concreting		277
Total labor days of 9 hours		17,419
Yds. concrete placed per day of total time		96.5
Yds. concrete placed per day of concreting time		130
Cost per yd. per man per day	$	0.482
Total average cost per cu. yd	$	1.49

Included in the above labor costs is the placing of 500,000 lbs. of steel reinforcement, or about 14 lbs. per cu. yd. of concrete, and the labor for erecting and dismantling the plant for handling the concrete. The rate of wages paid averages $0.344 per man per hour including the entire force employed.

HORSES AND MULES

The price of horses and mules varies very greatly with the locality, season of the year and also from year to year. Generally speaking, a good horse or mule costs from $200 to $350. A mule weighing 1,100 lbs. will do as much work as a horse weighing 1,400 lbs., and is less liable to sickness, can stand harder treatment, and eats slightly less than a horse. Twenty-eight mules bought in Kentucky and Missouri in 1910 were of an average weight of 1,100 lbs., average age 6 years and cost on an average of $255, including expenses of transporting to New York. As a rule a mare mule is more desirable than one of the other sex. A freight car load of horses or mules contains 22, an express car load 28. It takes about three weeks to acclimate a green animal. The annual depreciation of a horse used on construction work is about 15 per cent. In figuring the cost of feeding horses on construction work it should be appreciated that the horses will eat hay the whole year round, while they will require grain only during the period when they are actually working. Hay necessary for one horse for one day is 14 lbs. of hay grown by irrigation or 22 lbs. of cultivated timothy and red top or 30 lbs. of native hay. One horse or mule eats as much as three burros or jacks.

The average daily feed of each horse or mule used by the H. C. Frick Coke Company during a period of six years was 26 ears of corn (70 lbs. per bu.), 6 qts. of oats and 16½ lbs. of hay. A water supply sufficiently large to give 14 gallons of water to each horse should be allowed for.

In the southern portion of the United States horses on large jobs may work almost every day, but in the north it is ordinarily possible to obtain 180 days' work each year.

In a Brooklyn St. Ry. cost of feeding 2,000 horses was $20.00 per month each and the depreciation per horse was considered to be 25% per annum. Besides about 4 gallons of water per day each animal consumed the following amounts of food:

Feed Consumed.	Total (lbs.).	Pounds per Horse.	Cost per Horse.	Per Day.
Oats	14,281,172	7,690	$108.50	$0.2975
Hay	9,991,330	5,385	48.75	.1334
Straw	1,893,633	1,020	7.72	.0198
Bran	775,396	418	4.26	.0116
Meal	95,041	51	.85	.0023
Salt	122,267	66	.46	.0012
Corn	29,219	16	.25	.0007
			$170.79	$0.4665

According to some records in Manhattan, Bronx and Brooklyn, the cost with the average number of horses kept for this period

were as shown below, the costs and averages being figured on the basis of 365 days per year:

	Manhattan.	Brooklyn.	Totals and Averages.
Average number of horses kept	1,174	681	1,855
Stable rental	$ 41.44	$ 19.94	$ 33.50
Stable labor	237.00	268.00	248.00
Feeding and bedding	171.00	171.00	171.00
Shoeing	18.36	17.75	18.12
Veterinary	5.63	9.08	6.89
	$473.43	$475.77	

Mr. Richard T. Fox of Chicago, in a report to the Street Cleaning Department of Boston, gives the following figures:

Total number of horses owned by the department	128
Maintained directly by the department	95
Boarded by the Sanitary Department	33
Net cost per horse per year for rent, repairs, shoeing, veterinary services, medicine and feed	$517.83

Mr. Fox found that S. S. Pierce & Co., wholesale grocers of Boston paid $27.65 per horse per month for maintenance and shoeing, veterinary services and boarding in a public stable.

For shoeing, the Street Cleaning Department's bill amounted to $33.43 per year per horse. He found that Pierce & Co. paid a little less than $12.00 per year for veterinary services and medicine.

In constructing the water purification works at Springfield, Mass., the teaming and horse work was done mainly by teams owned by the company or hired and kept by it. The greatest number of horses owned was 43 and the greatest number hired and kept was 10. Hired horses cost $1.00 per day per horse for rent. A stable 100 ft. long by 30 ft. wide was constructed, and the equipment consisted of 20 bottom dump wagons, 6 wheel scrapers, caravans, express wagons, etc. The roads were in bad shape and had very heavy grades. All the horses were young and cost on an average $230 each, cost of shoeing and keeping these horses, including all expenses, was as follows:

COST OF TEAMING WORK—72,474 HORSE-HOURS.

Buildings.	Per Horse-hour.
Cost of materials used in building stable	$0.006
Cost of labor on same	.0033
Cost of proportion of material used in blacksmith shop	.0001
Cost of labor on same	.0010
Total cost of buildings	$0.0104
Depreciation and Repairs:	
Cost of depreciation on horses, including freight	$0.041
Cost of depreciation on harnesses and repairs on same	.01
Cost of depreciation on wagons and repair parts for same	.01
Cost of labor on wagon repairs	.0036
Total cost of depreciation and repairs	$.0646

Cost of insurance		$0.006
Cost of rent paid for hired horses		.02
Cost of teamsters and barn men		.1137
Cost of labor shoeing	$0.0055	
Cost of materials shoeing	.002	.0057
Cost of fodder of all kinds		.0845
Grand total cost of keeping horses per horse-hour actually used		$0.3067

Cost of single teams per hour	$0.39
Cost of double teams per hour	.605

The entire cost of the stable and a fair proportion of the cost of the blacksmith shop is charged against this one season's work. Had the horses been kept for the two seasons, the figure would be reduced one-half.

The depreciation on the horses represents the value of five horses lost and shrinkage in value of the remainder after one season's work. This figure would also probably show some improvement if extended through two or more seasons.

The wagons received rather severe usage under the steam shovel, and repair bills were correspondingly large.

A 4-horse team averaged 16½ miles per day over fine macadam roads as follows:

	Case I.	Case II.
Loads per day	14	7
Length of lead, ft	3,000	6,200
Level, ft.	2,400	2,400
5% Grade, ft.	600	3,800
Gross load, tons	3.65	3.15
Ton	0.65	0.65
Net load, tons	3.00	2.50
Tractive force on level, lbs	255.5	220.5
Tractive force on 5% grade, lbs	646.0	578.0
Duty per day, foot pounds	16,000,000	21,000,000

Mr. H. P. Gillette has maintained teams at the following per month per team:

½ Ton of hay, @ $10.00	$ 5.00
30 Bu. of oats, @ 35 cents	10.50
Straw for bedding	1.00
Shoeing and medicine	2.00
	$18.50

Twenty-five horses working for a period of 12 months on road construction in San Francisco, cost per horse per day as follows:

28	Lbs. wheat hay	@ $15.50 per ton	$0.215
12	Lbs. rolled barley	@ 24.10 per ton	0.150
1½	Lbs. oats	@ 27.40 per ton	0.020
¼	Lb. bran	@ 2.20 per ton	0.003
1⅓	Lbs. straw bedding	@ 13.80 per ton	0.009
			$0.397
Wages of stableman ($775 for 12 mos.) and hauling forage ($281 for 12 mos.)			0.113

Material packed on animals should be divided into two equal portions and slung on each side of the back. A fair load for a horse is 300 pounds, for a mule 200 to 300 pounds, for a burro 100 to 150 pounds, for a South American llama 50 to 75 pounds. However, the proper load for a pack animal varies with the size of the animal and the condition and grade of the road to be traveled.

HOSE

Rubber water hose, regular construction.

	Price per Foot ½ Inch Diameter.	Price per Foot 1 Inch Diameter.
2 Ply	$0.10	$0.12½
3 Ply	.12½	.20
4 Ply	.15	.25
6 Ply	.22½	.37½

Diameters run from ½ inch to 8 inches.

Rubber steam hose, regular construction.

	Price per Foot ½ Inch Diameter.	Price per Foot 1 Inch Diameter.
3 Ply	$0.23	$0.35
4 Ply	.28	.43
5 Ply	.35	.53
6 Ply	.42	.64
7 Ply	.49	.75
8 Ply	.56	.85

Diameters run from ½ inch to 3 inches.

The following table shows the proper ply hose for pressures of from 30 to 100 pounds:

	Heat Generated.				
30 Lbs.	= 274°	¾" 3-ply	1" 4-ply	1¼" 4-ply	1½" 5-ply
50 Lbs.	= 298°	¾" 4-ply	1" 5-ply	1¼" 5-ply	1½" 6-ply
60 Lbs.	= 307°	¾" 5-ply	1" 5-ply	1¼" 6-ply	1½" 6-ply
80 Lbs.	= 324°	¾" 5-ply	1" 6-ply	1¼" 7-ply	1½" 8-ply
90 Lbs.	= 331°	¾" 6-ply	1" 6-ply	1¼" 8-ply	1½" 9-ply
100 Lbs.	= 388°	¾" 6-ply	1" 7-ply	1¼" 8-ply	1½" 10-ply

Seamless cotton rubber lined hose.

Internal diam.	1"	1¼"	1½"	2"	2¼"	2½"	3"	3½"	4"
Price	$0.17	$0.22	$0.25	$0.30	$0.33	$0.35	$0.50	$0.75	$1.00

These prices do not include couplings. Unlined linen hose costs about half of the above.

Coverings for rubber hose designed to protect it from excessive wear may be woven cotton, wire wound, marlin woven or marlin wound. The disadvantages of various covers are as follows: In wire wound hose the wire is liable to cut the hose when the latter is stretched, woven cotton and marline absorb moisture and rot, marlin wound covering is liable to become loose as soon as one strand is cut. These coverings add about 15 per cent to the price of plain hose.

Metal tube hose consists of a metal armor with asbestos packing and a rubber coating. It is adapted for use with steam, gas, oil, or any fluid which has a tendency to cause rubber to deteriorate rapidly.

Size, diameter	½"	¾"	1"	1¼"	1½"
Price per foot	$0.90	$0.95	$1.20	$1.50	$1.80

A flexible metallic hose designed especially for hot water is a peculiarly prepared rubber cover with non-rustable metallic armor.

Size, diameter	1½"	2"	2¼"	2½"
Price, per foot..............	$0.70	$1.10	$1.25	$1.40

A flexible metallic hose designed to withstand the action of oil and air and fitted for rough service is covered with braided wire.

Size, diameter	¼"	½"	¾"	1"	1¼"	1½"
Price, single cover.......	$0.18	$0.25	$0.30	$0.44	$0.69	$0.79
Price, double cover........	.22	.30	.37	.53	.79	.96

An expecially strong flexible hose is armored inside and out, adapted for hard service with drills, etc.

Size, diameter ...	½"	¾"	1"	1¼"	1½"	1¾"	2"	2½"	3"
Price, per foot...	$0.45	$0.55	$0.70	$0.80	$0.97	$1.25	$1.50	$2.00	$2.50

Suction hose reinforced spirally with flat wire is made with smooth bore for use on large dredges and centrifugal pumps and rough bore for use on diaphragm and small steam pumps.

Internal diameter		¾"	1"	1½"	2"	3"	5"
Price per foot, rough bore.		$0.28	$0.36	$0.60	$0.92	$1.60	$3.00
Price per ft., smooth bore.		.32	.40	.68	1.05	1.80	3.40
Internal diameter	6"	8"	10"	12"	15"	20"	21"
Price per foot, rough bore	$3.80	$6.00	$8.00	$ 8.80			
Price per foot, smooth bore	$4.20	$6.35	$9.00	$10.80	$16.00	$27.00	$30.00

HYDRAULIC MINING GIANTS

The nozzles first used in hydraulic mining ranged from plain pipe or hose to simple nozzles. The first improvement in discharge pipes was a flexible horizontal iron joint formed by two elbows, one working over the other, with a coupling joint between them. These elbows were called "Goose Necks." These joints were very defective, the water pressure causing them to move hard and "buck." The evolution of the hydraulic nozzle was from the "Goose Neck" to the "Globe Monitor"; then, successively, the "Hydraulic Chief," "Dictator," and "Little Giant." The "Hydraulic Giant" is a modification of the Little Giant, and is shown in Fig. 168.

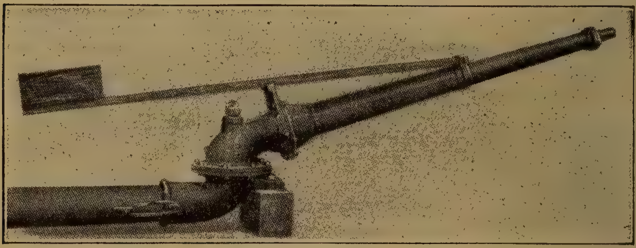


Fig. 168. Hydraulic Mining Giant.

Under high pressure the "deflector," which is fitted to the butt of the discharge and carries the nozzle, should be used. By means of the "deflector" the Giant can be turned with the greatest ease. In the table of sizes, weights, etc., of Giants, the column headed "Approximate Amounts of Gravel Washed in 24 Hours" is based on the assumption that the water carries about 2.86 per cent of solid material. This percentage varies widely and depends upon a number of conditions, but mainly upon the nature of the soil, direction of washing, and slope of the sluices. Under extremely favorable conditions it is possible to carry as large a percentage as 20 or 25, but in many cases the proportion of earth to water is as 1 to 200 or more.

TABLE 124—DOUBLE-JOINTED, BALL-BEARING HYDRAULIC MINING GIANTS.

Size Number.	Diam. of Pipe Inlets (Ins.).	Diam. of Butts with Nozzle Attachment. (Inches.)	Effective Head in Feet.	Size of Nozzle Supplied and Flow in Cubic Feet per Minute That Will Pass the Nozzles Under the Given Head.		Approx. Amount of Gravel (Average Ground) Washed in 24 Hours. (Cubic Yards.)		Weight of Heaviest Part. (Pounds.)	Shipping Wt. (Pounds.)	Approximate Prices. Double-Jointed. Ball-Bearing.	Approximate Prices. Deflectors.
				1" Nozzle	1½" Nozzle	1" Nozzle	1½" Nozzle				
0	5	2½	100	26.46	59.16	40	90	100	330	$ 97.00	.....
			150	32.40	72.48	50	110				
			200	37.26	83.64	60	130				
				2" Nozzle	3" Nozzle	2" Nozzle	3" Nozzle				
1	7	4	100	104.88	236.22	160	370	120	390	135.00	$47.00
			200	148.32	334.08	230	520				
			300	181.61	409.20	280	640				
			400	209.82	472.50	320	730				
				3" Nozzle	4" Nozzle	3" Nozzle	4" Nozzle				
2	9	5	100	236.22	420.06	370	650	150	520	188.00	52.00
			200	334.08	594.00	520	920				
			300	409.20	727.56	640	1,130				
			400	472.50	840.12	730	1,300				
				3" Nozzle	4" Nozzle	3" Nozzle	4" Nozzle				
3	11	6	200	334.08	594.00	520	920	210	890	240.00	56.00
			300	409.20	727.56	640	1,130				
			400	472.50	840.12	730	1,300				

JACKS

TABLE 125—HYDRAULIC JACKS.

Plain Jacks:						
Tons lift	4	7	10	20		
Run out, inches.......	12	18	24	18		
Height, inches	24	32	39	33		
Price, dollars..........	48	58	88	116		
Weight, pounds	50	75	110	155		
Broad Base Jacks:						
Tons lift	4	7	10	20	30	50
Run out, inches.......	12	18	18	18	18	12
Height, inches	25	31	31	32½	33	28
Price, dollars	50	60	70	110	150	190
Diam. of base, inches.	9½	10	12	13	13¼	15
Weight, pounds	65	97	130	206	260	320
Screw Jacks:						
Number	1	4	8	13	17	
Diam. of screw, inches	1¼	1½	1¾	2	2½	
Height when down, in.	8	12	16	20	24	
Net rise, inches.......	4	7	10	13	18	
Whole height, in......	12	19	26	33	42	
Est. lift cap., in.......	5	8	12	15	20	
Weight, pounds	9½	22	33	45	82	
Price	$2.00	$3.00	$4.00	$6.40	$10.40	

LABOR AND WAGES

UNION WAGES IN NEW YORK CITY

The following table shows the prevailing rate of wages for various classes of union labor in New York City. When not otherwise stated the rate given is per day:

	April 6, 1910.	April 5, 1911.
Asbestos workers	$ 4.50	$ 4.50
Asbestos workers' helpers	..	2.80
Architectural iron workers	4.80	4.80
Bluestone cutters	4.50	4.50
Bluestone cutters' helpers	2.80	3.00
Blasting foremen	4.00	4.00
Bricklayers and masons, per hour	.70	.70
Blacksmiths, average	4.06	4.00
Boiler makers, Brooklyn	3.25	...
Boiler makers, Queens, per hour	.32	...
Boiler makers, Richmond	3.20	...
Building material handlers, per 1,000	.40	.40
Caisson and foundation workers	3.50	3.50
Carpenters and joiners, Brooklyn	4.50	4.50
Carpenters and joiners, Queens	4.00	4.00
Carpenters and joiners, Manhattan	5.00	5.00
Carpenters and joiners, Bronx	4.50	4.50
Carpenters and joiners, Richmond	4.00	4.00
Cement masons, all boroughs	5.00	5.00
Cement and asphalt laborers	2.80	3.00
Cement workers	2.80	2.80
Chandelier makers	3.00	...
Coppersmiths	4.50	...
Derrickmen and riggers	3.75	3.75
Double drum hoister runners	4.00	4.00
Drop forgers	3.50	3.50
Dock builders, average	4.00	4.00
Decorative glass workers, average	3.50	...
Decorative glass art workers	...	5.00
Electric linemen	4.00	...
Electric linemen, Brooklyn	...	4.00
Electric linemen, Manhattan	...	4.00
Electric linemen, Richmond	...	4.00
Electric inside wiremen	4.50	4.50
Electric fixture workers	4.50	4.50
Electric helpers	2.20	2.20
Elevator constructors	4.50	5.00
Elevator constructors' helpers	...	3.20
Excavators, per hour	.22	.22
Engineers, portable	5.50	5.50
Engineers, stationary	4.50	4.50
Engineers (marine)	...	3.27
Framers	5.00	5.00
Firemen, Queens	...	2.60
Firemen, Bronx, average, per trip	...	4.25
Firemen, Richmond	...	2.04
Granite cutters	4.50	$4.50 & $5
Housesmiths	4.80	4.80
Housesmiths and bridgemen	4.80	5.00
Highway laborers	2.25	2.25
House shorers and movers	3.50	3.50
House shorers' helpers	...	2.65
Iron workers	...	5.00
Iron workers' helpers	...	3.50
Iron workers' apprentices	...	3.00
Lathers, Brooklyn, per bunch	27½c	27½c

UNION WAGES IN NEW YORK CITY—Continued.

	April 6, 1910.	April 5, 1911.
Lathers, Queens, per 1,000	2.75	2.75
Lathers, Manhattan	4.50	4.50
Lathers, Bronx	4.50	4.50
Lathers, Richmond	3.25	3.25
Laborers, Brooklyn, per hour	37½c	37½c
Laborers, Manhattan, per hour	37½c	37½c
Laborers, Queens, per hour	37½c	37½c
Laborers, Richmond, per hour	37½c	37½c
Machine stone workers	4.25	4.00
Marble cutters and setters	5.00	5.00
Marble carvers	5.50	5.50
Marble bed rubbers	4.50	5.00
Marble sawyers	4.75	4.75
Marble cutters' helpers	3.00	3.00
Marble polishers	4.25	4.50
Machinists, Brooklyn	...	3.75
Machinists, Manhattan	...	5.00
Machinists' apprentices, average, per week	...	7.00
Metallic lathers	...	5.00
Millwrights	4.50	...
Mosaic workers	...	4.50
Mosaic workers' helpers	...	3.00
Paper handlers, average, per week	15.00	15.00
Painters and decorators, Brooklyn	4.50	4.50
Painters, Queens	3.28	3.28
Painters and decorators, Manhattan	4.50	4.50
Painters, Bronx	4.00	4.00
Painters, Richmond	3.00	3.00
Paperhangers	6.00	Price list
Pavers, Brooklyn	5.00	5.00
Pavers, Manhattan	5.00	5.00
Pipe calkers and tappers	4.00	4.00
Plasterers, Brooklyn	5.50	5.50
Plasterers, Queens	5.50	5.50
Plasterers, Manhattan	5.50	5.50
Plasterers, Bronx	5.50	5.50
Plasterers' laborers	3.25	3.25
Plate and sheet glass glaziers	...	3.50
Plumbers, Brooklyn	5.00	5.50
Plumbers, Manhattan	5.00	5.50
Plumbers, Bronx	5.00	5.00
Plumbers, Richmond	5.00	5.50
Plumbers' laborers	3.00	3.00
Rock drillers	3.50	3.50
Roofers, Brooklyn	4.00	4.00
Roofers, Queens	4.50	4.50
Roofers, Manhattan	4.75	5.00
Roofers, Richmond	4.00	4.00
Rockmen, per hour	.30	.30
Riggers	3.50	4.00
Stone cleaners and pointers	3.06	3.06
Stone cutters, Brooklyn, per hour	62½c	62½c
Stone cutters, Manhattan	4.00	4.00
Steam shovel cranemen, per month	124.00	124.00
Stair builders	5.00	5.00
Steam fitters	5.00	5.00
Steam fitters' helpers	3.00	3.00
Stone masons, Brooklyn, per hour	.55	.55
Stone masons, Manhattan, per hour	.55	.55
Stone setters	5.50	5.50
Stationary firemen	2.00	2.00
Tar, felt and waterproof workers	3.75	3.75
Tile layers	5.00	5.00
Tile layers' helpers	3.00	3.00
Terra cotta workers, average	2.95	2.95

TABLE 126—LABOR COSTS FOR TOWNS AND CITIES IN UNITED STATES, COMPILED FROM DATA PUBLISHED IN ENGINEERING AND CONTRACTING

NEW ENGLAND DIVISION

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
MAINE												
Auburn	..	..	9	....	....	$1.75	....	....	$4.00	....	....	$4.00
Bath	..	..	10	....	....	1.75	....	....	2.00	....	....	4.00
Lewiston	..	9	9	....	$1.75	1.75	....	....	4.00	....	....	4.00
Portland	9	9	9	$1.75	1.75	1.75	$3.50	$3.50	3.50	$5.00	$5.00	5.00
NEW HAMPSHIRE												
Laconia	9	..	..	1.75	....	....	....	....	....	4.50	....	....
VERMONT												
Barre	9	9	..	1.75	1.75	....	5.00	....	....	4.00	4.00	....
St. Albans	9	..	..	1.75	....	....	....	....	....	4.00	....	....
MASSACHUSETTS												
Andover	9	..	..	2.00	....	....	5.00	....	....	5.00	....	....
Boston	8	9	..	2.00	1.75	....	5.00	....	....	5.00	4.00	....
Brookline	..	9	..	....	1.75	....	....	....	....	....	....	....
Cambridge	8	8	8	2.00	2.00	2.00	5.00	....	3.50	6.00	6.00	5.00
Easthampton	9	..	..	2.00	....	....	....	....	....	5.00	....	....
Everett	8	8	8	2.00	2.00	2.00	5.00	4.50	5.00	4.50[2]	4.50[1]	3.25
Fitchburg	..	8	8	2.00	....	*.22	....	....	*.50	....	4.00	*.50
Greenfield	8	..	..	1.75	....	....	....	....	....	4.50	....	....
Haverhill	..	8	8	....	2.25	2.25	....	4.50	†2.50	....	4.50	5.00
Holyoke	8	..	8	2.00	....	*.25	2.50	....	2.25	4.50	....	4.50
Hyde Park	8	..	..	2.00	....	....	2.75	....	....	5.00	....	....
Lawrence	8	8	..	2.25[3]	2.00	....	4.00[4]	5.00	....	5.00	5.00	....
Lowell	8	8	8	2.00	2.00	2.00	4.00	4.00	4.00	5.00	5.00	5.00
Lynn	8	..	8	2.40	....	2.25	3.80	....	....	3.76[5]	....	5.25
Malden	..	8	..	....	2.00	....	....	....	....	....	3.50	....
New Bedford	8	8	8	2.25[6]	2.25	2.00	2.75	2.75	....	4.50	4.50	5.00
Newburyport	8	..	..	2.00	....	....	2.00	....	....	4.00	....	....
Newton	..	8	8	....	2.00	2.00	....	....	....	....	5.25	5.25[24]
Pittsfield	8	..	..	2.00	....	....	....	....	....	5.00	....	....

MASSACHUSETTS—Continued.

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Somerville	..	..	8	....	....	1.75[32]	....	....	4.50[33]	....	....	3.50[34]
Southbridge	9	..	..	2.00	....	....	....	....	....	4.50	....	....
Springfield	8	8	8	2.25	2.25	1.75	2.50	2.25[7]	....	5.25	5.00	5.00
Waltham	..	8	..	....	2.00	....	....	....	....	....	....	....
Westfield	8	..	..	2.00	....	....	5.00	....	....	5.00	....	....
Woburn	8	..	..	2.00	....	....	....	....	....	4.00	....	....
Worcester	8	8	8	1.85	2.00	....	4.00	4.00	4.00	5.50	6.00[8]	4.50
RHODE ISLAND												
Newport	..	..	8	....	....	2.00	....	....	3.00	....	....	5.00
Pawtucket	..	..	9	....	....	1.77	....	....	2.80	....	....	4.56[4]
Providence	9	9	9	1.75	.17[5]	.17*	2.52	.28[5]	.28*	4.50	.50[5]	.45[30]
East Providence	9	..	..	1.75	4.00	....	4.00	....	....	3.00[7]	....	....
CONNECTICUT												
Ansonia	9	..	9	1.75	....	1.65	....	....	....	5.00	....	5.00
Bridgeport	10	8	..	1.65	1.25	....	....	2.25	....	6.00	6.00	....
Bristol	9	..	..	1.75	....	....	3.00	....	....	5.00	....	....
Hartford	10	9[3]	10	1.75	1.75	1.75	....	5.00	5.00	6.00	5.00	6.00
Meriden	..	9	..	....	1.75[4]	....	....	2.50	....	....	.60[6]	....
Middletown	..	10	..	....	1.85	....	....	....	....	....	4.50	....
New Briton	..	9	..	....	1.75	....	....	4.00	....	....	5.00	....
New London	9	..	..	1.75	....	....	....	....	....	4.50	....	....
Norwalk	9	..	..	1.75[8]	....	....	....	....	....	5.00	....	....
Stamford	..	..	..	....	1.75	....	....	2.00	....	....	5.00	....
Torrington	10	..	..	1.50	....	....	....	....	....	5.50	....	....
Waterbury	10	..	..	1.75	....	....	....	....	....	5.00	....	....
Willimantic	10	..	..	1.75	....	....	4.50	....	....	1.75	....	....

MIDDLE ATLANTIC DIVISION

NEW YORK

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Albany	..	..	8	....	....	1.75	....	....	4.50	....	....	6.00
Amsterdam	8	8	..	1.75	1.62	....	3.00	....	....	5.00	4.50	....
Auburn	8	..	..	1.75	....	....	....	....	....	4.50	....	....
Binghamton	8	8	8	1.75	1.65	1.50	2.00	2.50	2.50	4.00	3.50	3.50
Buffalo	8	8	8	2.00	1.75	1.75	4.00	4.00	.40*	6.00	4.80	6.00

NEW YORK—Continued.

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Corning	..	8	..	....	1.60	....	....	....	....	....	3.50	....
Cortland	8	..	..	1.60	....	....	....	....	....	3.50	....	....
Dunkirk	..	8	..	....	1.75	....	....	3.00	....	....	4.50	....
Elmira	8	..	8	1.75	....	1.50	2.50	....	2.75	3.50	....	3.50
Fulton	..	8	..	....	1.60	....	....	3.00	....	....	4.00	....
Herkimer	8[9]	..	..	1.75	....	....	....	....	....	4.00	....	....
Hornell	8	8	..	1.75	1.75	....	2.00	3.00	....	3.20	3.20	....
Hudson	8	8	..	1.50	1.50	....	4.00	....	....	4.00	5.00	....
Jamestown	8	8	..	1.60	1.75	....	2.50	2.50	....	4.00	4.25	....
Johnstown	8	..	..	1.75	....	....	2.50	....	....	4.50	....	....
Kingston	8	8	8	2.00	1.75	1.50	3.50	4.00	6.00	4.50	4.00	4.00
Little Falls	8	8	..	1.75	1.65	....	....	3.50	....	4.00	4.00	....
Middletown	..	8	..	....	2.00	....	....	2.75	....	....	4.50	....
Mount Vernon	8	..	..	1.75	....	....	....	....	....	5.00	....	....
Niagara Falls	8	8	..	1.62	1.75	....	2.00	.35[5]	....	6.00	5.50	....
North Tonawanda	8	10	..	1.60	1.75	....	2.40	2.25	....	5.00	5.00	....
Norwich	8	..	..	1.85	....	....	5.00	....	....	4.50	....	....
Ogdensburg	..	8	..	....	1.75	....	....	....	....	....	3.50	....
Olean	..	8	..	....	.20[5]	....	....	.40[5]	....	....	.50[5]	....
Oneida	8	8	..	1.75	1.75	....	5.00	4.00	....	5.00	4.50	....
Oneonta	8	8	..	2.00	1.75	....	....	4.00	....	5.00	4.00	....
Plattsburg	8	..	..	1.50	....	....	5.00	....	....	3.50	....	....
Port Jarvis	9	8	..	....	....	....	....	....	....	....	....	....
Rochester	8	8	10	2.00	2.00	.21*	4.00	3.20	.50*	5.00	5.00	4.50
Schenectady	8	8	..	2.00	1.75	....	2.50	....	....	5.00	6.00	....
Syracuse	8	8	8	1.70	1.70	1.60	4.00	4.00	3.50	4.50[10]	4.50	4.50[38]
Troy	..	8	8	....	1.75	1.50	....	....	4.00	....	5.00	5.00
Utica	8	8	8	1.75	1.75	1.60[12]	4.00	3.00	....	4.00	4.50	4.00
Watertown	8	8	8	1.75	1.75	1.75	3.00	4.00	....	4.00	4.00	4.00
Watervliet	8	..	..	1.60	....	....	5.00	....	....	5.00	....	....
White Plains	8	8	..	1.75	1.65	....	....	....	....	5.00	5.00	....
NEW JERSEY												
Asbury Park	9	..	..	1.75	....	....	4.00	....	....	4.00	....	....
Bayonne	..	9½	..	....	1.75	....	....	....	....	....	6.00	....
Camden	10	10	10	1.50	1.50	1.50	2.50	3.00	3.00	5.00	5.00	5.00
Elizabeth	9	8	9	1.75	1.75	1.75	5.00	5.00	5.00	5.00	5.00	5.00

NEW JERSEY—Continued.

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Hoboken	..	9	9	....	....	1.75[13]	....	....	4.50[14]	....	....	6.50
Jersey City	8	8	..	2.00	2.00	....	5.00	5.00	....	6.00	6.00	....
Newark	..	..	..	1.75	....	....	5.00	....	....	5.50[11]	....	....
New Brunswick	10	10	..	1.75	1.65	....	4.00	5.00	....	5.50	5.00	....
Passaic	..	..	10	....	....	1.50	....	....	....	....	5.50	....
Plainfield	8	..	..	1.75	....	....	....	....	....	5.00	....	....
Summit	9	..	..	1.75	....	....	....	....	....	5.50	....	....
Trenton	10	..	10	1.75	....	1.60	3.50	....	4.00	6.00	....	5.00
Westfield	9	..	..	1.75	....	....	....	....	....	5.00	....	....
West New York	9	..	..	2.00	....	....	5.00	....	....	6.00	....	....
West Orange	9	..	..	2.00	....	....	4.00	....	....	5.00	....	....

PENNSYLVANIA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Butler	9[12]	..	..	1.75	....	....	2.00	....	....	5.00	....	....
Carbondale	9	..	..	1.75	....	....	2.25	....	....	5.00	....	....
Carlisle	10	..	..	1.40	....	....	....	....	....	3.50	....	....
Chester	10	..	..	1.50	....	....	3.00	....	....	5.00	....	....
Clearfield	10	..	..	1.60	....	....	....	....	....	4.00	....	....
Donora	9	..	..	1.65	....	....	3.00	....	....	5.00	....	....
Du Bois	9	..	..	1.75	....	....	2.50	....	....	4.00	....	....
Easton	..	..	9	....	....	.20*	....	....	....	....	....	.50*
Erie	10	10	10	1.75	1.75	1.60	2.50	....	2.50	4.50	....	4.50
Franklin	10	..	..	1.75	....	....	....[13]	....	....	5.00	....	....
Greenville	9	..	..	1.80	....	....	3.00	....	....	5.00	....	....
Harrisburg	9	..	9	1.50	....	1.50	....	....	2.25	....	....	4.50
Hazelton	10	..	..	1.50	....	....	4.00	....	....	5.50	....	....
Lancaster	10	..	..	1.25	....	....	....	....	....	....	....	....
Luzerne	10	..	..	1.60	....	....	....	....	....	....	....	....
Meadville	10	..	..	1.75	....	....	3.00	....	....	4.00	....	....
Monongahela	9	..	..	1.70	....	....	2.50	....	....	5.50	....	....
New Brighton	10	..	..	1.70	....	....	2.70	....	....	6.00	....	....
New Castle	9	9	9	1.60	1.50[9]	1.50	3.50	3.50	3.50	5.00	4.50	5.00
Norristown	..	..	10	....	....	1.50	....	4.50[25]	....	....	....	5.00[26]
Oil City	10	..	..	1.75	....	....	2.25	....	....	5.00	....	....
Pittsburgh	10	..	..	1.75	....	....	6.00	....	....	5.00	....	....
Pottstown	10	..	..	1.60	....	....	....	....	....	3.50	....	....
Punxsutawny	9	..	..	1.60	....	....	....	....	....	....	....	....

PENNSYLVANIA—Continued.

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Rankine	9	..	..	1.60	....	....	2.50	....	....	5.50	....	....
Reading	..	8	10	....	1.60	1.50[31]	....	2.50	3.00	....	3.60	4.50
Sayre	10	..	..	1.75	....	....	4.00	....	....	4.00	....	....
Scranton	10	10	10	1.60	1.50	1.50	2.75	2.50	2.75	4.50	5.00	5.00
Shamokin	9	..	..	1.80	....	....	4.00	....	....	4.00	....	....
Shenandoah	9	..	..	1.75	....	....	3.50	....	....	5.00	....	....
South Bethlehem	10	..	..	1.50	....	....	....	....	....	4.50	....	....
Swissvale	9½	..	..	1.71	....	....	3.325	....	....	5.00	....	....
Tyrone	10	..	..	1.75	....	....	....	....	....	4.50	....	....
Warren	8	..	..	2.00	....	....	....	....	....	....	....	....
Washington	10	..	..	1.65	....	....	2.50	....	....	5.00	....	....
Wilkesbarre	9	10	10	1.75	1.60	1.50	3.00	3.00	....	4.50	4.50	4.50
Wilkensburg	10	..	..	1.60	....	....	2.00	....	....	5.00	....	....
Williamsport	..	10	..	....	1.75	....	....	2.50	....	....	4.00	....
York	10	..	..	1.75	....	....	....	....	....	4.00	....	....

EAST NORTH CENTRAL DIVISION

OHIO

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Akron	..	..	8	....	....	2.00	....	....	3.50	....	....	4.50[1]
Ashtabula	10	..	..	2.00	....	....	2.50	....	....	5.00	....	....
Barberton	10	..	..	1.65	....	....	3.00	....	....	5.00	....	....
Bucyrus	10	..	..	2.00	....	....	3.50	....	....	4.50	....	....
Cambridge	9	..	..	2.00	....	....	....	....	....	4.05	....	....
Canton	10	..	10	1.75	....	....	4.00	....	....	5.00	....	5.00
Chillicothe	10	..	..	1.75	....	....	1.75[14]	....	....	4.50	....	....
Circleville	10	..	..	1.65	....	....	4.00	....	....	4.00	....	....
Columbus	10	8	10	1.90	2.00	1.75	3.00	3.00	3.00	4.50	4.00	4.00
Conneaut	9	..	..	1.80	....	....	....	....	....	5.00	....	....
Coshocton	9	..	..	1.75	....	....	2.00	....	....	4.00	....	....
Dayton	10	10	..	1.75	2.00	....	2.50	3.50	....	4.50	4.50	....
Delaware	10	..	..	1.75	....	....	....	....	....	3.50	....	....
East Liverpool	8½	..	9½	1.85	....	1.75	3.00[15]	....	3.00	5.00	....	5.00
Fostoria	10	..	..	2.00	....	....	....	....	....	4.50	....	....
Findlay	..	..	10	....	....	2.00	....	....	2.50[8]	....	....	4.00
Fremont	10	..	..	2.00	....	....	4.00	....	....	4.50	....	....
Galion	10	..	..	1.80	....	....	4.00	....	....	4.00	....	....
Hamilton	10	10	10	2.00	2.00	1.50[12]	....	3.00	....	4.00	4.50	4.50

OHIO—Continued.

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Lancaster	10	..	..	1.50	....	....	2.50	....	....	3.50	....	....
Lima	10	10	..	1.75	2.00	....	4.00	3.50	....	4.00	4.00	....
Lorain	10	10	..	1.75[16]	1.75	....	2.50	....	....	4.50	4.50	....
Massillon	9	..	..	1.80	....	....	2.50	....	....	4.00	....	....
Mount Vernon	10	..	..	1.75	....	....	2.00[17]	....	....	3.50[18]	....	....
Newark	..	9	..	....	1.80	....	....	2.50	....	....	4.50	....
Niles	10	..	..	1.75	....	....	....	....	....	4.50	....	....
Norwood	9	..	..	1.75	....	....	....	....	....	5.00	....	....
Ravenna	10	..	..	1.75	....	....	3.50	....	....	4.50	....	....
Springfield	10	10	..	2.00	2.00	....	5.00	5.00	....	4.00	8.00	....
Toledo	..	..	8[40]	....	....	1.50[41]	....	....	3.50	....	....	.50*
Wooster	10	..	..	2.00	....	....	3.00	....	....	4.00	....	....
Zanesville	8	10	10	1.75	1.75	1.75	2.50	3.00	3.00	5.00	4.00	4.00

INDIANA

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Anderson	10	10	..	2.00	1.75	....	....	....	....	3.50	3.50	....
Bedford	10	..	..	1.75	....	....	3.00	....	....	4.00	....	....
Bloomington	10	10	..	1.75	1.75	....	2.50	2.50	....	3.50	3.50	....
Crawfordsville	8	..	..	1.75	....	....	4.00	....	....	4.00	....	....
Elkhart	10	..	..	2.00	....	....	....	....	....	4.00	....	....
Evansville	10	8	..	1.60	1.60	....	3.00	2.75	....	4.00	4.00	....
Fort Wayne	10	..	10	2.00	....	1.75	2.75	....	5.00	4.50	....	3.25[10]
Frankfort	10	..	..	2.00	....	....	3.00	....	....	4.00	....	....
Gary	10	10	..	2.00	2.00	....	5.00	4.50	....	6.00	6.00	....
Indianapolis	8	..	10	1.60	....	2.00	2.50	....	2.50	3.50	....	4.00
Kokomo	10	..	..	2.00	....	....	....	....	....	3.50	....	....
La Porte	10	..	..	2.25	....	....	3.50	....	....	4.50	....	....
Linton	10	..	..	....	....	....	....	....	....	....	....	....
Logansport	10	..	9	2.00	....	2.00	5.00	....	....	4.00	....	4.00
Marion	..	..	10	1.75	....	....	4.00	....	....	4.25	....	....
Mishawaka	10	..	..	....	....	1.50	....	....	.30*	....	....	3.50
Muncie	10	..	..	2.00	....	....	....	....	....	4.00	....	....
New Albany	..	10	10	....	1.50[13]	1.50	....	....	1.75	....	3.50	3.00
New Castle	10	..	..	2.00	....	....	3.00	....	....	4.00	....	....
Richmond	10	10	10	1.75	1.75	1.75	2.50	2.50	2.50	3.50	3.75	3.75
Seymour	10	..	..	1.75	....	....	2.50	....	....	3.00	....	....
South Bend	..	..	10	....	....	1.75[35]	....	....	....	....	....	4.00

INDIANA—Continued.

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Terre Haute	9	..	10	1.65	....	1.50	2.50	....	3.00	3.50	....	3.50
Valparaiso	..	..	10	....	....	2.00	....	....	2.50	....	....	4.00
Washington	10	..	..	1.50	....	....	....	....	....	....	....	....
ILLINOIS												
Alton	10	..	..	1.75	....	....	2.50	....	....	4.00	....	....
Aurora	..	9	10	....	1.80	2.25	....	....	....	....	5.85	5.00
Bloomington	10	..	10	2.25	....	2.00	4.00	....	3.50	4.50	....	4.50
Cairo	8[19]	10	10	1.50	1.50	1.50	....	4.00	3.00	3.50	4.00	4.00
Chicago Heights	10	..	..	2.00	....	....	....	....	....	4.30	....	....
Danville	10	..	..	2.00	....	....	3.00[20]	....	....	4.00	....	....
Decatur	..	..	9	....	....	2.00	....	....	2.50	....	....	4.00
East St. Louis	..	..	8	....	....	1.75[4]	....	....	2.50[5]	....	....	3.50[6]
Edwardsville	9	..	..	2.00	....	....	4.00	....	....	5.00	....	....
Elgin	..	..	10	....	....	2.00	....	....	2.75	....	....	4.50
Evanston	..	9	9	....	2.50	2.50	....	5.00	4.00	....	5.50	5.40
Freeport	10	10	10	2.00	2.00	2.00[11]	3.00	4.00	3.00	5.00	5.00	4.50
Granite City	10	..	..	2.00	....	....	4.50	....	....	5.00	....	....
Harrisburg	8	..	..	2.00	....	....	....	....	....	4.00	....	....
Jacksonville	9	..	..	1.50	....	....	....	....	....	4.00	....	....
Joliet	9	..	..	2.00	....	....	5.00	....	....	6.00	....	....
LaGrange	10	..	..	2.75	....	....	....	....	....	6.00	....	....
LaSalle	8	..	..	2.40	....	....	4.50	....	....	4.80	....	....
Macomb	9	..	..	1.75	....	....	2.50	....	....	4.50	....	....
Marion	..	9	..	....	1.75	....	....	.40[5]	....	....	4.00	....
Mattoon	..	10	..	2.00	2.00	....	3.00	....	....	4.00	4.00	....
Mount Carmel	10	..	..	1.75	....	....	3.00	....	....	4.00	....	....
Oak Park	9	..	..	....	....	....	....	....	....	....	....	....
Olney	9	..	..	1.75	....	....	2.25	....	....	3.50	....	....
Ottawa	10	9	10	2.00	2.00	2.00	....	2.50	4.00	4.50	4.50	4.00
Pekin	9	..	..	2.00	....	....	....	....	....	3.50	....	....
Peoria	8	10	10	2.00	2.00[14]	1.75	3.00	4.50	**	4.00	4.00[15]	3.50
Rockford	8	8	8	2.00	2.00	2.00	5.00	4.00	4.00	4.00	4.00	4.00
Rock Island	..	9	..	....	2.25	....	....	2.50	....	....	4.50	....
Springfield	10	..	9	1.75	....	1.80	2.50	....	2.25	4.50	....	4.00
Streator	8	8	8	2.00	2.25	2.25	3.00	2.50	3.00	4.50	4.50	4.00
Waukegan	9	8	..	2.25	2.25	....	3.00	4.50	....	5.20	.65[5]	....

MICHIGAN

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Alpena	10	..	..	1.75	....	....	4.00	....	....	4.00	....	....
Ann Arbor	9	..	..	2.00	....	....	....	....	....	4.50	....	....
Battle Creek	10	10	10	2.25	2.25	2.00	4.00	3.50	3.50	5.00	4.50	4.00
Bay City	..	..	10	....	....	2.00	....	....	4.50	....	....	4.00
Benton Harbor	9	..	..	1.75	....	....	2.25	....	....	4.50	....	....
Cheboygan	10	..	..	1.75	....	....	....	....	....	4.00	....	....
Coldwater	10	..	..	2.00	....	....	....	....	....	4.00	....	....
Detroit	10	..	10	2.25	....	2.00	3.25	....	3.50	5.00	....	5.00
Escanaba	10	..	..	2.00	....	....	....	....	....	4.50	....	....
Flint	10	10	..	2.00	2.00	....	3.50	3.00	....	4.50	4.00	....
Grand Rapids	10	10	10	2.00	2.00	2.00	3.00	3.00[11]	3.00	4.50	4.00[12]	4.50
Hillsdale	10	..	..	1.75	....	....	....	....	....	3.50	....	....
Holland	10	..	..	2.00	....	....	2.50	....	....	4.00	....	....
Lansing	..	10	..	....	2.00	....	....	....	....	4.50	....	....
Kalamazoo	9	9	..	2.00	1.80	....	2.75	3.00	....	4.50	4.05	....
Manistee	..	..	10	....	....	1.50[21]	....	....	....	....	....	3.50[22]
Muskegon	..	9	10	....	2.00	1.75	....	....	....	....	5.00	4.00
Pontiac	10	..	..	2.50	....	....	....[22]	....	....	5.00	....	....
Port Huron	9	9	10	2.00	1.75	1.75	5.00	3.00	3.00	5.00	5.00	4.00
Saginaw	10	10	9	2.25	2.00	2.00	2.75	2.50	2.25	4.00	4.00	4.00
St. Joseph	9	..	..	1.75	....	....	4.00	....	....	4.00	....	....

WISCONSIN

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
Antigo	10	..	..	2.00	....	....	....	....	....	4.00	....	....
Fond du Lac	10	..	..	2.00	....	....	3.50	....	....	5.00	....	....
La Crosse	..	..	10	....	....	1.75[18]	....	....	3.00	....	....	4.50
Madison	..	..	9	....	....	2.00	....	....	....	....	....	4.50
Menasha	10	..	..	2.00	....	....	....	....	....	4.00	....	....
Marinette	10	..	..	1.75	....	....	....	....	....	4.00	....	....
Merrill	10	..	..	1.50	....	....	....	....	....	3.50	....	....
Milwaukee	..	10	..	....	2.00	....	....	5.00	....	....	5.00	....
Racine	..	10	10	....	2.00	2.00	....	....	4.00	....	6.00	5.00
Sheboygan	10	..	..	2.00	....	....	....	....	....	4.00	....	....
Superior	10	..	10	2.25	....	2.25	4.50	....	....	5.00	....	5.00
Waukesha	10	..	..	2.25	....	....	....	....	....	4.50	....	....
Wausau	10	..	..	1.75	....	....	....	....	....	4.00	....	....

MINNESOTA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Albert Lea	..	10	..	....	2.00	....	....	4.00	....	....	4.50	....
Bemidji	10	..	..	2.25	....	....	5.00	....	....	4.50	....	....
Crookston	10	..	..	2.25	....	....	....	....	....	4.00	....	....
Mankato	10	10	10	2.00	2.00	1.75	4.00	....	....	4.00	4.00	3.50
Minneapolis	8	8	8	2.25	2.25	2.00	2.75[23]	4.00	2.50[23]	4.72	4.80	4.00
Winona	9	..	..	1.75	....	....	2.25	....	....	4.00	....	....

WEST NORTH CENTRAL DIVISION

IOWA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Ames	..	9	..	....	2.25	....	....	3.00	....	....	4.00	....
Brookfield	9	..	..	1.80	....	....	3.60	....	....	3.60	....	....
Burlington	10	10	..	1.75	2.00	....	2.50	3.00	....	4.00	4.50	....
Cedar Rapids	10	..	9	2.00	....	2.50	2.50	....	3.50	4.40	....	4.50
Chariton	..	10	..	....	2.00	....	....	3.00	....	....	4.00	....
Charles City	..	..	..	2.00	....	....	....	....	....	4.00	....	....
Clinton	..	..	10	....	....	2.00	....	....	4.00	....	....	4.00
Council Bluffs	10	10	..	2.50	1.75	....	5.00	3.00	....	5.00	3.50	....
Creston	10	..	..	2.00	....	....	3.50	....	....	4.00	....	....
Davenport	10	10	10	2.00	2.00	22-25*	4.00	3.00	.30*	5.00	5.00	5.50
Dubuque	10	..	10	2.00	....	2.00	2.50	....	2.50	5.00	....	4.50
Fort Dodge	10	..	10	2.00	....	2.25[8]	....	....	4.00	4.50	....	4.75
Keokuk	9	9	..	2.00	1.75	....	3.00	2.25	....	4.00	3.75	....
Iowa City	..	9	..	....	1.75[17]	....	....	....	....	....	4.00	....
Marshalltown	10	..	..	2.00	....	....	5.00	....	....	4.00	....	....
Mason City	10	..	..	2.00	....	....	4.00	....	....	4.00	....	....
Muscatine	..	10	..	....	2.00	....	....	....	....	....	....	....
Ottumwa	10	10	..	2.00[25]	2.00[18]	....	2.50[26]	2.50	....	4.00[27]	4.50	....
Sioux City	10	8	10	2.00	2.25	2.25	5.00	5.00	4.00	4.00	4.00	4.00
Waterloo	10	10	..	2.00	2.00	....	3.00	2.50	....	4.50	4.50	....

MISSOURI

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Columbia	10	..	..	1.75	....	....	2.00	....	....	3.50	....	....
Fulton	10	..	..	1.75	....	....	3.00	....	....	3.50	....	....
Jefferson City	9	..	..	1.75	....	....	3.50	....	....	3.50	....	....
Kansas City	8	..	8	1.75	....	.20*	5.00	....	....	5.00	....	.50*
Kirksville	9	..	..	2.00	....	....	....	....	....	3.50	....	....

MISSOURI—Continued.

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Lexington	10	..	..	1.75	....	....	2.00[23]	....	....	4.00	....	....
Moberly	9	..	..	2.00	....	....	3.50	....	....	3.50	....	....
St. Charles	10	..	..	1.75	....	....	....	....	....	4.00	....	....
St. Louis	10	10	10	1.75	2.00	1.75	4.00	3.50	4.00	5.00	5.00	5.00
Sedalia	10	..	..	1.75	....	....	3.00	....	....	3.50	....	....
Springfield	..	..	10	....	....	1.50	....	....	2.00[36]	....	....	3.00[37]
Webb City	9[29]	..	..	2.00	....	....	4.50	....	....	3.50	....	....

WEST NORTH CENTRAL DIVISION

NORTH DAKOTA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Grand Forks	10	..	..	2.50	....	....	3.00	....	....	5.00	....	....
Grand Island	8	..	..	....	....	....	....	....	....	....	....	....
Fremont	10	..	..	2.50	....	....	3.50	....	....	4.00	....	....

NEBRASKA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Lincoln	8	10	10	2.00	2.00	1.75[19]	3.00	3.00	2.50	4.00	5.00	4.00[20]
South Omaha	10	10	8	1.75[30]	2.00	2.00	4.00[31]	4.50	5.00	6.00	5.00	5.50

KANSAS

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Atchison	8	..	..	1.80[32]	....	....	2.50[33]	....	....	3.50[34]	....	....
Coffeyville	8	8	..	1.75	1.50	....	....	....	....	2.75	3.50	....
Emporia	8	..	..	2.00	....	....	....	....	....	4.00	....	....
Fort Scott	8	..	..	1.75	....	....	2.00[35]	....	....	3.20	....	....
Hutchinson	8	..	..	2.00	....	....	4.00	....	....	4.00	....	....
Independence	8	8	..	1.65	1.60[16]	....	3.00	3.00	....	3.20	3.20	....
Kansas City	8	..	..	1.75	....	....	2.50	....	....	4.00	....	....
Lawrence	..	8	8	....	1.75	1.60	....	2.50	2.00	....	3.50	3.50
Leavenworth	..	8	8	....	1.75	1.75	....	3.00	3.75	....	3.50	3.50
Manhattan	8	..	..	1.75	....	....	3.00	....	....	4.00	....	....
Newton	8	..	..	2.00	....	....	....	....	....	3.50	....	....
Ottawa	8	..	..	1.60	....	....	2.00	....	....	3.20	....	....
Pittsburg	8	..	..	1.60[36]	....	....	2.00	....	....	3.00	....	....
Salina	8	..	..	1.50	....	....	2.50	....	....	3.50	....	....
Topeka	8	8	8	1.75	1.75	1.75	2.50	3.00	3.50[39]	3.50	4.00	4.00
Wellington	8	..	..	1.60	....	....	....	....	....	3.20	....	....
Wichita	8	8	..	1.75	1.75	....	2.00	....[19]	....	3.25	3.50	....

SOUTH ATLANTIC DIVISION

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
MARYLAND												
Annapolis	..	8	8	....	1.25	1.25	....	4.00	....	....	2.25	2.50
Baltimore	8	..	..	1.75	....	....	4.50	....	....	5.00	....	....
Cumberland	..	..	9	....	....	1.50	....	....	2.50	....	....	2.75
Frederick	10	..	..	1.50	....	....	4.50	....	....	5.00	....	....
Hagerstown	10	..	..	1.50	....	....	1.80	....	....	3.00	....	....
Washington, D. C.	8	8	8	1.50	1.50	1.50	2.00[37]	3.50	2.50[13]	4.00	4.00	4.00[44]
VIRGINIA												
Danville	10	10	..	1.25	1.25	....	1.50	1.75	....	3.50	3.50	....
Norfolk	..	9	..	....	1.50	....	....	3.75	....	....	5.00	....
Portsmouth	10	..	..	1.50	....	....	....	....	....	5.00	....	....
Staunton	10	..	..	1.50	....	....	....	....	....	3.50	....	....
Suffolk	10	..	..	1.25	....	....	2.00	....	....	4.50	....	....
WEST VIRGINIA												
Clarksburg	10	..	..	1.75	....	....	2.50	....	....	5.00	....	....
Wheeling	..	..	9	....	....	1.75	....	....	2.25	....	....	4.50
NORTH CAROLINA												
Asheville	10	..	..	1.25	....	....	....	....	....	....	....	....
Charlotte	..	..	10	....	....	1.00	....	....	2.00	....	....	4.00
Greensboro	10	..	..	1.25	....	....	1.50	....	....	2.50	....	....
Newbern	10	..	..	1.25	....	....	3.00	....	....	4.00	....	....
SOUTH CAROLINA												
Charleston	9	9	9	1.35	1.25	1.25	3.00	3.00	3.00	2.00	2.00	5.00
Columbia	10	..	..	1.25	....	....	....	....	....	4.00	....	....
Greenville	10	..	..	1.25	....	....	2.00	....	....	4.00	....	....
Spartanburg	10	..	..	1.00	....	....	1.00	....	....	3.00	....	....
GEORGIA												
Americus	10	..	..	1.50	....	....	2.25	....	....	4.00	....	....
Brunswick	9	..	..	1.50	....	....	....	....	....	5.00	....	....
Dublin	10	..	..	1.25	....	....	....	....	....	....	....	....

GEORGIA—Continued.

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Macon	..	10	..	....	1.50	....	....	4.00	....	....	3.50	....
Rome	10	..	..	1.50	....	....	2.50	....	....	3.50	....	....
FLORIDA												
Gainesville	10	..	..	1.25	....	....	2.00	....	....	3.50	....	....
Pensacola	..	10	10	....	1.50	1.50	....	....	3.00	....	4.50	4.00
Tallahassee	9	..	..	1.00	....	....	....	....	....	4.00	....	....
KENTUCKY												
Covington	..	..	..	....	....	1.75	....	....	3.00	....	....	5.00
Lexington	10	..	..	1.50	....	....	2.50	....	....	4.00	....	....
Louisville	10	9	..	1.75	1.75	....	3.50	3.00	....	4.00	4.00	....
Owensboro	10	..	..	1.75	....	....	....	....	....	4.00	....	....
Paris	10	..	..	1.50	....	....	....	....	....	4.00	....	....
TENNESSEE												
Knoxville	10	..	10	1.35	....	1.25[16]	....	....	....	3.50	....	3.50[17]
ALABAMA												
Dotham	10	..	..	1.25	....	....	....	....	....	4.00	....	....
Gadsden	10	10	..	1.25	1.75	....	3.00	3.00	....	3.50	4.00	....
Selma	..	..	10	....	....	1.00	....	....	1.75	....	....	4.00
Talladega	10	..	..	1.25	....	....	....	....	....	....	....	....
MISSISSIPPI												
Meridian	10	..	10	1.25	....	1.25	....	....	2.00	3.50	....	3.75
Vicksburg	10	10	10	1.35	1.50	1.25	2.00	2.50	1.25	4.00	4.00	4.00
WEST SOUTH CENTRAL DIVISION												
ARKANSAS												
Fort Smith	..	..	9	....	....	1.75	....	....	5.00	....	....	3.25[10]
Jonesboro	10	..	..	1.50	....	....	3.50	....	....	4.00	....	....
Little Rock	..	10	10	....	1.50	1.50	....	2.50	3.50	....	4.50	4.50
Pine Bluff	..	..	10	....	....	1.50	....	....	2.50	....	....	3.50

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
LOUISIANA												
New Orleans	10	..	..	2.00	....	....	3.50	....	....	7.00	....	....
OKLAHOMA												
Bartlesville	8	..	..	2.00	....	....	4.00	....	....	4.00	....	....
Durant	8	..	..	2.00	....	....	2.50	....	....	4.00	....	....
Enid	..	8	..	....	2.00	....	....	4.00	....	....	3.50	....
McAlester	..	8	..	....	2.00	....	....	....	....	....	3.50	....
Muskogee	8	8	..	1.75	1.75	....	2.25	2.00[20]	....	4.00	4.00	....
Oklahoma City	8	8	..	2.00	2.00	....	4.00	2.50	....	4.50	4.00	....
Sapulpa	8	..	..	2.00	....	....	....	....	....	....	....	....
Shawnee	8	..	..	1.60	....	....	2.00	....	....	3.50	....	....
Tulsa	8	..	..	2.00	....	....	3.50	....	....	4.00	....	....
TEXAS												
Beaumont	..	..	9	....	....	1.75	....	....	3.00	....	....	5.00
Dallas	..	..	..	2.00	....	....	....	....	....	4.00	....	....
Greenville	10	..	..	1.75	....	....	3.50	....	....	3.50	....	....
Longview	10	..	..	....	....	....	....	....	....	....	....	....
Port Arthur	8	..	..	....	....	....	....	....	....	5.00[38]	....	....
San Angelo	9	..	..	1.75	....	....	....	....	....	....	....	....
San Antonio	8	8	..	1.50	1.50	....	1.50	1.75	....	3.00	3.00	....
Temple	8	..	..	1.50	....	....	5.00	....	....	4.00	....	....
Weatherford	10	..	..	1.50	....	....	....	....	....	3.00	....	....
Wichita Falls	10	..	..	2.00	....	....	....	....	....	3.00	....	....
Waco	8	..	..	1.50	....	....	....	....	....	3.00	....	....
MOUNTAIN DIVISION												
MONTANA												
Billings	8	..	..	3.00	....	....	....	....	....	5.00[39]	....	....
Butte	8	8	8	....	3.50	3.50	8.00	6.00	4.00	7.00	7.00	7.00
Great Falls	8	..	..	3.00	....	....	4.00	....	....	6.00	....	....
Helena	8	8	8	3.00	3.00	3.00	7.00	7.00	7.00	6.00	5.50	6.00
Missoula	8	..	..	3.00	....	....	....	....	....	6.50	....	....
IDAHO												
Boise	8	9	..	2.50	2.50	....	....	....	....	5.00	5.00	....
Twin Falls	10	..	..	3.00	....	....	....	....	....	5.00	....	....

City	Working Hours 1911	Working Hours 1910	Working Hours 1909	Common Labor 1911	Common Labor 1910	Common Labor 1909	Pavers 1911	Pavers 1910	Pavers 1909	Teams & Drivers 1911	Teams & Drivers 1910	Teams & Drivers 1909
COLORADO												
Boulder	8	..	..	2.25	....	....	....	....	....	5.00	....	....
Denver	..	..	8	....	....	2.00	....	....	....	....	....	5.00
Grand Junction	8	..	..	2.50	....	....	5.00	....	....	4.50	....	....
NEW MEXICO												
Albuquerque	9	..	..	1.75	....	....	....	....	....	4.50	....	....
UTAH												
Ogden	..	9	..	....	2.25	....	....	....	....	....	4.00	....
Provo	..	..	8	....	....	2.00	....	....	....	....	....	5.00
Salt Lake City	8	10	8	2.25	2.00	2.25	....	....	2.50	5.00	4.50	5.00
PACIFIC DIVISION												
WASHINGTON												
Aberdeen	..	8	..	....	2.50	....	....	....	....	....	6.00	....
Bellingham	8	..	..	2.25	....	....	5.00	....	....	6.00	....	....
Centralia	8	..	..	2.50	....	....	7.00	....	....	6.00	....	....
Hoquiam	8	8	..	2.50	2.50	....	3.00	5.00	....	7.00	7.50	....
Everett	..	8	..	....	2.25	....	....	6.00	....	....	6.00	....
North Yakima	..	8	..	....	2.50	....	....	....	....	....	5.00	....
Seattle	8	8	8	2.50	2.25	2.25	5.50	4.50	6.00	6.50	6.50	6.50
Spokane	8	8	8	3.00	3.00	2.75	3.50	3.50	3.50	6.00	6.00	5.50
Tacoma	..	8	8	....	2.50	2.50	....	....	6.00	....	6.00	6.00
Vancouver	8	8	..	2.35	2.25	....	....	3.00	....	6.00	6.50	....
Walla Walla	8	8	..	2.25	2.25	....	....	....	....	5.00	5.00	....
OREGON												
Ashland	10	..	..	2.25	....	....	....	....	....	7.00	....	....
Baker	10	..	..	2.50	....	....	....	....	....	5.00	....	....
Medford	10	..	..	2.75	....	....	3.50	....	....	5.00	....	....
Portland	9[40]	..	8[28]	2.25[41]	....	2.25	3.50[42]	....	4.50	6.00	....	5.00[29]
Salem	..	..	..	....[43]	....	....	....	....	....	5.00	....	....

CALIFORNIA

City	Working Hours 1911	1910	1909	Common Labor 1911	1910	1909	Pavers 1911	1910	1909	Teams & Drivers 1911	1910	1909
Berkeley	..	9	..	....	2.50	....	....	....	....	....	5.00	....
Eureka	8	..	..	2.50	....	....	....	....	....	5.00	....	....
Fresno	8	8	8	2.00	2.00	2.50	3.50	4.00	....	4.00	4.50	4.00
Los Angeles	..	8	..	....	2.00	....	....	....	....	....	4.00	....
Napa	8	..	..	2.50	....	....	4.00	....	....	5.00	....	....
Pasadena	..	8	..	....	2.50	....	....	....	....	....	5.00	....
Pomona	8	..	..	2.00	....	....	....	....	....	4.00[44]	....	....
Richmond	8	..	..	2.50	....	....	3.00	....	....	5.50	....	....
San Bernardino	9	..	..	2.25	....	....	....	....	....	4.50	....	....
San Diego	8	10	..	2.00	2.25	....	....	3.50	....	....	5.00	....
San Francisco	..	8	..	....	2.50[21]	....	....	6.00	....	....	6.50	....
San Jose	9	9	9	2.25	2.00	2.00	....	....	....	6.00	5.00	5.00
Santa Barbara	8	..	..	2.00	....	....	....	....	....	4.00	....	....
Santa Cruz	8	..	..	2.00	....	....	....	....	....	....	....	....

1909

* Per hour; † city labor; ** paid at rate of 5 cents per square yard laid.

[1]$4.50 to $5; [2]$4 to $6; [3]$5 to $6; [4]$1.75 to $2; [5]$2.50 to $3; [6]$3.50 to $4; [7]$1 to $2.50 for city teams, $3.25 to $4.50 for hired teams; [8]$2.50 to $3; [8]$2.25 to $2.50; [9]$4 to $6; [10]$3. 25 to $3.50; [11] $2 to $2.25; [12]$1.50 to $1.75; [13]$1.25 to $1.75; [14]$4 to $4.50; [15]$3.50 to $4; [16]$1.25 to $1.75; [17]$3.50 to $4; [18]$1.75 to $2; [19]$1.75 to $2; [20]$4 to $5; [21]$1.50 to $2; [22]$3. 50 to $4; [23]$2.50 to $3.50; [24]$3.50 for single team, $5.25 for double team; [25]$4.50 to $5; [26]single team $3, double $5; [27]single team, $2.84, double team, $4.50; [28]8 to 10 hrs.; [29]$5 to $6; [30]28 cents per hour for single team, 45 cents per hour for double team; [31]$1.50 to $1.75; [32]$1.75 to $2.25; [33]$4.50 to $5; [34]single team; [35]$1.75 to $2; [36]$2 to $3; [37]$3 to $3.50; [38]$4.50 to $5; [39]$3.50 to $4; [40]8 to 9 hrs.; [41]$1.50 to $1.75; [42]$1.60 to $2; [43]$2.50 to $3.50; [44]2-horse $4, cart $2.

1910

[1]$4.50 for double team, $3.25 for single team; [2]paid at rate of 22 cents per square yard laid; [3]9 to 10 hours; [4]$1.75 to $2.25; [5]per hour; [6]$5.25 for double team, $3.50 for single; [7]$2.25 to $2.50; [8]single team $4, double team $6; [9]$1.50 to $1.75; [10]$1.75 to $2.25; [11]$3 to $4; [12]$4 to $5; [13]$1.50 to $1.70; [14]$2 to $2.25; [15]$4 to $4.50; [16]1.60 to $1.75; [17]$1.75 to $2; [18]$2 to $2.25; [19]3 cents per square yard; [20]$2 to $3; [21]$2.50 to $3.

1911

[1]$4.50 and $5; [2]$4.50 per double team, $3.25 per single team; [3]$2 to $2.25; [4]$4 to $6; [5]$3.76 per single team, $5.28 per double team; [6]$2.25 for city; [7]$3 per single, $4.50 per double team; [8]$1.75 to $2; [9]8 and 9 hours; [10]$4.50 and $5; [11]$5.50 and $6 [12]9 and 10 hours; [13]paid at rate of 28½ cents per square yard laid; [14]$1.75 and $3; [15]$3 to $5; [16]$1.75 and $2.50; [17]$2 and $2.50; [18]$3.50 and $4; [19]8 and 10 hours; [20]$3 and $3.50; [21]$1.50 to $1.75; [22]paid at the rate of 3 cents per square yard laid; [23]$2.75 to $3.50; [24]$3.50 to $4.50; [25]$2 to $2.25; [26]$2.50 to $3; [27]$4 to $4.50; [28]$2 to $2.50; [29]9 and 10 hours; [30]$1.75 and $2; [31]$4 and $5; [32]$1.80 and $2; [33]$2.50 and $3; [34]$3.50 and $4; [35]$2 or 3½ cents per square yard laid; [36]$1.60 to $1.75; [37]$2 to $3.50; [38]$5 and $6; [39]$5 to $6; [40]9 to 10 hours; [41]$2.25 to $2.60; [42]$3.50 to $4.50; [43]paid at rate of 25 cents per hour; [44]$4 to $5.

UNION WAGES IN CHICAGO.

From *Engineering News* we reprint the following list of positions in the Engineering Service, Class "B," city of Chicago, 1912:

	No. of Positions.	Average Salaries.
Assistant architectural draftsman..........	8	$1,095.00
Draftsman	9	1,187.00
Laboratory engineering assistant	3	1,080.00
Map draftsman	19	1,131.00
Rodman	41	1,116.00
Totals and average, grade I............	80	$1,131.00
Architectural draftsman	10	$1,566.80
Assistant engineering chemist	6	1,500.00
Clerk of the works..........................	5	1,500.00
Electrical engineer	1	1,620.00
Engineering draftsman	11	1,535.00
Junior engineer	31	1,521.00
Map engineering draftsman..................	9	1,487.00
Mechanical engineering draftsman	12	1,510.00
Plan examiner	2	1,830.00
Title searcher	2	1,800.00
Totals and average, grade II...........	89	$1,535.00
Architectural designer	6	$2,093.33
Architectural engineer	8	2,220.00
Assistant engineer	24⅓	2,102.00
Assistant superintendent of construction....	4	2,600.00
Bridge designing engineer	3	1,788.00
Building inspector in charge...............	1	2,500.00
Chief draftsman, maps and plats...........	1	1,740.00
City forester	1	2,000.00
Deputy smoke inspector in charge..........	1	1,800.00
Designing engineer	1	1,794.00
Electrical designing engineer	1	2,400.00
Engineering chemist	2	1,960.00
Examiner of efficiency (technical)..........	3	1,920.00
Expert asphalt chemist	1	2,400.00
Heating and ventilating designing engineer.	1	2,400.00
Mechanical designing engineer	2	1,800.00
Sanitary designing engineer................	1	1,920.00
Totals and average, grade III..........	61⅓	$2,111.00
Assistant chief engineer, sewers	1	$2,700.00
Assistant chief engineer, streets............	1	2,700.00
Chief architectural designer	1	3,600.00
Chief deputy smoke inspector..............	1	3,000.00
Chief street engineer	1	3,600.00
City architect	1	4,500.00
Deputy commissioner of buildings..........	1	4,000.00
Engineer (harbor, wharves and bridges)....	⅓	3,000.00
Engineer in charge of bridges..............	1	5,000.00
Engineer of bridge construction and repairs	1	3,000.00
Engineer of bridge design	1	3,600.00
Engineer of tests	1	3,000.00
Engineer of track elevation	1	4,200.00
Engineer of water surveys	2	3,000.00
Engineer of water works construction......	1	4,000.00
Engineer of water works design............	1	3,600.00
Expert on system and organization.........	1	3,000.00
Mechanical engineer in charge.............	1	7,500.00
Secretary and engineer.....................	1	3,600.00
Superintendent of construction............	1	3,200.00

UNION WAGES IN CHICAGO—Continued.

	No. of Positions	Average Salaries
Superintendent, maps and plats	1	4,000.00
Superintendent, water pipe extension	1	4,500.00
Supervisor mechanical engineer and chief deputy inspector	1	3,000.00
Third assistant superintendent of streets in charge of street repairs	1	3,600.00
Totals and average, grade IV	24⅓	$3,695.00
Architect, board of education	1	$6,000.00
Assistant architect, board of education	1	4,000.00
Assistant city engineer	1	5,000.00
City engineer	1	8,000.00
Engineer, board of local improvements	1	3,600.00
Totals and average, grade V	5	$5,320.00
Total number of positions		270
Total salaries		$484,354.00
Average salaries		1,796.00

The hours of labor established by law in California are eight, and the following are the rates paid by the San Diego County commission on highway work during 1910.

Camp superintendents (foremen), per month and board	$125.00
Sub-foreman, per month and board	70.00
Blacksmiths, per month and board	75.00
Timekeepers, per month and board	50.00
Cooks, per month and board	60.00
Flunkeys or scullions, per month and board	35.00
Corral bosses, per month and board	40.00
Night watchman, per month and board	35.00
Freight drivers, per month and board	40.00
Water wagon drivers, per month and board	40.00
Carpenters, per day	4.00
Carpenters' helpers, per day	2.25
Teamsters (2 or 4 horses per day)	2.25
Teamsters (6 horses or more), per day	2.75
Plow holders, per day	2.75
Wheeler loaders, per day	2.50
Wheeler dumpers, per day	2.50
Snatch drivers, per day	2.50
Drillers, per day	2.25
Blacksmith helpers, per day	2.25
Fresno loaders, per day	2.00
Cart drivers, per day	2.00
Common laborers, per day	2.00
Team of 2 animals and harness, per day and board	1.00
Team of 2 animals, harness and driver, per day and board.	3.25
Team of 2 animals, harness and driver, per day	4.25

Compressed air workers in New York City have made a new wage agreement with the contractors whereby they will be paid in accordance with the air pressure rather than the depth to which the caissons are sunk. The new scale is as follows: $3.50 a day for six hours' work at 22 lbs. pressure; $3.75 a day for six hours at 30 lbs. pressure; $4.00 a day for four hours at 30 to 35 lbs. pressure; $4.25 a day for three hours at 35 to 40 lbs. pressure, and $4.50 a day for 1 hour 20 min. work at 40 to 45 lbs. pressure.

On B. & O. R. R. bridge across the Susquehanna River the above were paid as follows:

Elevation 0 to —55 ft.:	
Foreman, eight hours	$4.00
Laborers, eight hours	2.75
Elevation —55 to —70 ft.:	
Foreman, six hours	$4.25
Laborers, six hours	3.00
Below —70 ft.:	
Foremen, four hours	$4.50
Laborers, four hours	3.25
Locktenders (outside), per hour	.20

LADDERS

Straight rung ladders of seasoned spruce or pine, with white ash or oak rungs, 20 cents per foot. Extension ladders, furnished with improved lock, 30 cents per foot.

Lead costs about 6 cents per lb. in ton lots.

Lead Wool is put up in strands which should be placed in the joint one at a time and each strand thoroughly caulked before the next strand is added. It is extremely valuable where the trench is wet or where the pipe is under pressure, as it can be used under water, whereas molten lead cannot. Caulking is somewhat difficult if ordinary methods are pursued, but by the use of an outfit such as is described under "Air Compressors" this difficulty is obviated. The manufacturers claim a saving in

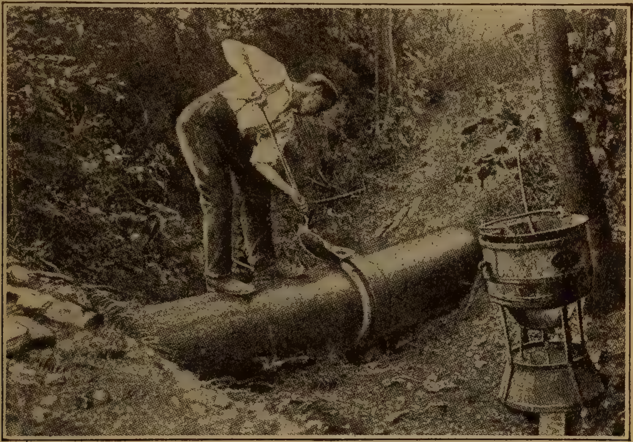


Fig. 169. Section of 13-mile Pipe Line Installed at Reedsville, Pa. Gasoline Furnace in Foreground.

amount necessary to caulk a joint as compared with cast lead, as shown by the following:

Diam. of pipe, inches	3	4	6	8	10	12	16	20	24	30	36
Cast lead required, Pounds	5	6	9	13	17	20	30	40	65	90	103
Maximum amount of lead wool required, Pounds	..	..	6	10	12	14	20	28	40	60	65

It costs, in lots of not less than 200 lbs., including caulking tools, 9 cents per lb., and in ton lots 8¾ cents per lb., f. o. b. New York. (See Air Compressors.)

Leadite, a substitute for lead used in jointing cast iron water mains, comes in powder form, packed in sacks of 100 lbs. and barrels of 350 lbs. One ton of this material is equivalent to four tons of lead and requires no caulking. Price for less than car load, 10 cents per lb., f. o. b. Philadelphia.

LEVELS

An architect's or builder's dumpy level with an 11-in. telescope, weighs 4 lbs. and costs $35.00. The tripod weighs 6 lbs. An architect's or builder's Y level with an 11-in. telescope weighs 5 lbs. and costs $45.00; with compass, $60. The tripod weighs 6 lbs.

An architect's or builder's convertible Y level with 11½-in. telescope weighs 6 lbs. and costs $60; with compass, $75.00. The tripod weighs 6 lbs.

An engineer's dumpy level with 15 to 18-in. telescope, weighs 7½ lbs. and costs $100. The tripod weighs 8 lbs.

An engineer's railroad Y level with 15 to 18-in. telescope weighs 10 lbs. and costs $110. The tripod weighs 8 lbs.

An engineer's Y level with 15 to 18-in. telescope weighs 11 lbs. and costs from $100 to $150, averaging $135. The tripod weighs 9 lbs.

Precision levels with 18-in. telescopes, weighing 12 pounds, cost from $150 to $300. Tripods weigh 9 to 15 lbs.

LIGHTS

Some construction work must be done at night, and much of it can be expedited if certain portions are done after the regular day shift has knocked off.

For instance, a macadam road must be finished in a limited time, the road to be surfaced is straight-away from the quarry, dock or siding where the stone is procured and the only economical way of hauling the stone is along the finished road. It is almost impossible, or at least very difficult, to use more than

Fig. 170.

one gang. In such a case it is obvious that if the stone is unloaded, hauled and spread at night the work will be facilitated. There is no reason why this should not be done. Proper lights are necessary however.

Many steam shovels, cranes and derricks are operated at night. Darkness offers no obstacle to the working of cableways, belt conveyors and other conveying machinery if the loading and unloading places are properly illuminated. The means of lighting work may be anything from candles to electric light. Kerosene consumes five times and candles seven times as much oxygen as acetylene. Kerosene gives off nine and candles ten times the product of combustion given off by acetylene. The light of kerosene and candles is obscured by the smoke given off by them; whereas, the light of acetylene and electricity is not thus interfered with.

CONTRACTORS' LIGHTS AND TORCHES.

Contractors' lights are made in a number of different types of which we illustrate the most important.

Kerosene Burning Lights (Fig. 170) are made by several companies and the usual form consists of a cylindrical tank, with proper valves and feed pipes, and a support for the burner. They can be used for heating as well as lighting, and are very useful as paint burners, for boiler repairs, and for melting lead joints in water pipe.

Catalog Size.	Candle Power.	Length of Flame.	Gals. of Oil per Hr.	Size of Tank.	Gross Weight in Lbs.	Net Weight in Lbs.	Price.
No. 3...	2,000	30″	1 —1½	1—½′x2′	220	120	$53.00
No. 5...	4,000	36″	1½—2	1—½′x2′	220	130	58.00

Fig. 171. Carriage for light, $14.50. Tripod outfit, $9.50.

Fig. 171.

Carbide Burning Lamps consist of an outer tank holding water, an inner tank holding carbides, and the pipe and burner. These lights are not usually affected by wind or rain and burn water and calcium carbide in about even proportions. Calcium carbide costs about 4 cents per lb. in 100 lb. drums.

Fig. 172 illustrates a light of this type the capacities, etc., of which are given below.

Catalog Size.	Candle Power.	Burning Capacity.	Net Weight.	Gross Weight.	Carbide Consumed.	Price.
No. 2...	1,000	10 hrs.	60 lbs.	100 lbs.	6 lbs.	$38.40
No. 3...	3,000	10 hrs.	65 lbs.	110 lbs.	10 lbs.	52.80
No. 5...	5,000	10 hrs.	75 lbs.	120 lbs.	18 lbs.	60.00
No. 55..	10,000	10 hrs.	90 lbs.	150 lbs.	35 lbs.	96.00

No. 5 S, similar to No. 5, but equipped with 25 feet of armored hose ....$ 77.00
No. 55 S, similar to No. 55, but equipped with 25 feet of armored hose 120.00

Extra tripod attachment with hose and extra reflector, $27.00.

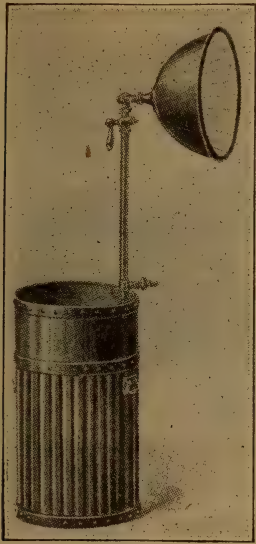


Fig. 172.

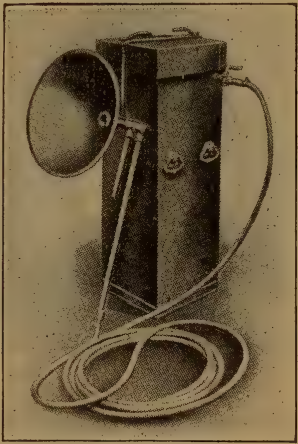


Fig. 173.

Another lamp of this type is illustrated in Fig. 173 and its particulars follow.

Catalog. Size	Candle Power.	Burn. Cap. Hrs.	Distance, Lit. Ft.	Ship'g Weight, Lbs.	Carbide Consumed Lbs.	Price.	Equipment.
No. 2......	3,000	5	1,000	85	6	$ 50.00	Standpipe
No. 2W....	3,000	5	1,500	85	6	65.00	3 ft. hose
No. 3X.....	5,000	5	1,500	125	18	83.00	Standpipe
No. 3W....	5,000	9	1,500	225	18	98.00	25 ft. hose
No. 4Z.....	10,000	12	3,000	223	32	114.00	Standpipe
No. 4W.....	10,000	8½	3,000	250	32	146.00	2 ft. hose
No. 1......	50	10		15	2	13.50	Hand lamp
Builders ..	100	10		28	2½	25.00	Hand lamp

Tripod and 25 ft. of armored hose with fittings, extra......$18.00

An Electric Light especially designed of low voltage, for use on construction work is illustrated in Fig. 174 and consists of a steam turbine engine directly connected to a dynamo (weight 327 lbs., size 30 ins. x 18 ins. x 18 ins.), and these in turn connected by cable to a portable arc lamp with a special reflector in a waterproof case (weight 92 lbs.). Carbons which cost about

2½ cents each burn from eight to nine hours. That part of the lamp most likely to wear is the cummutator brush, which may need renewing after three weeks' work. Price of outfit complete, $220. This lamp gives a steady light and is unaffected by wind or rain.

Oil and Vapor Torches, familiarly known as banjo torches, consisting of a pan shaped tank for holding the kerosene or gasoline

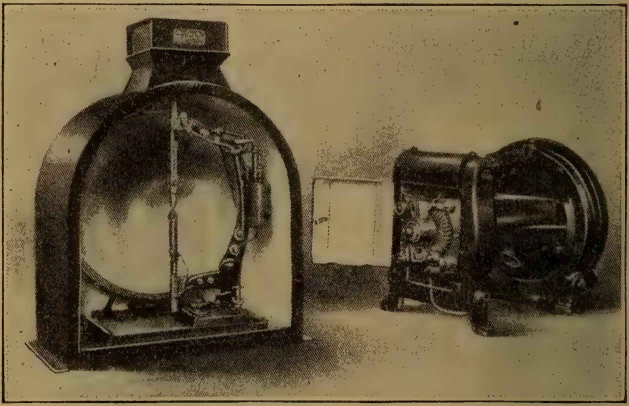


Fig. 174.

fuel, a gravity feed pipe, and a burner, for use in lighting small spaces are manufactured in many varieties, but are alike in the general method of operation. A novel use of these torches was for heating green concrete sewer pipe during cold weather. Price, per dozen, 1 gallon tank, $12.00; 6-qt. tank, $15.00.

LIME AND PLASTER

New York Prices. The following are the wholesale current prices in 500 bbl. lots or more delivered to the trade in New York City. For the retail prices or prices for the material delivered to the contractor's jobs in truck load lots as required, about 25 cents per bbl. should be added to these.

LIME.

State common, cargo rate, per bbl.		@$ 0.75
Rockland-Rockport, com., per bbl.		.92
Rockland-Rockport, L., per bbl.	$1.02	....
Rockland-Rockport, special, 320 lbs.		1.37
Select finish, per 350 lbs., net.	1.60	...

Terms for Rockland-Rockport lime, 2 cents per bbl. discount, net cash, ten days for 500 bbl. lots.

West Stockbridge, finishing, 325 lbs.	...	$ 1.40
New Milford lime.	...	1.30
New Milford (small barrel)	...	1.00
Hydrated, per ton.	$8.00	9.00

PLASTER PARIS.

Calcined, city casting, in barrels, 250 lbs.	...	1.45
In barrels, 320 lbs.	...	1.65
In bags, per ton.	$8.50	10.00
Calcined, city casting, in barrels, 250 lbs.	...	1.45
In barrels, 320 lbs.	...	1.65
Neat wall plaster, in bags, per ton*	...	8.00
Wall plaster, with sand, per ton.	...	5.25
Browning	...	5.25
Scratch	...	6.25

*When sold in bags a rebate of 6¼ cents per bag returned is allowed.

LOCOMOTIVES

The tractive force or drawbar pull of a locomotive is its pulling strength in pounds measured by a dynamometer. The larger the cylinders and the greater the steam pressure, the greater the tractive force; the larger the diameter of the driving wheels, the less the tractive force.

Let T represent the tractive force.
Let D represent the diameter of the cylinders in inches.
Let L represent the length of stroke of the pistons in inches.
Let 0.85 p represent 85 per cent of the boiler pressure in pounds per square inch.
Let d represent diameter of the driving wheels in inches.

$$\text{Then } T = \frac{D^2 \times L \times 0.85\,p}{d}$$

Example: To find the tractive force of a locomotive with cylinders 10 ins. in diameter by 16 ins. stroke, 150 lbs. boiler pressure, and driving wheels 33 ins. in diameter:

$$T = \frac{10^2 \times 16 \times 0.85 \times 150}{33} = 6{,}182 \text{ lbs.}$$

Mr. H. P. Gillette says: "It is very commonly stated that 20 lbs. is the force required to pull a 2,000-lb. load over light rails. This may be so over carefully laid, clean track, with ties close-spaced and with car wheels well lubricated; but over the ordinary, rough, contractor's track 20 lbs. is much too low an estimate.

"In the 'Coal and Metal Miners' Pocket Book' is a table giving actual results of traction tests, including several hundred separate tests under varying conditions. From these tables I have summarized the following:

	Per Short Ton.
Pull to start mine cars (old style) loaded................	90 lbs.
Pull to start mine cars (new style) empty................	80 lbs.
Pull to keep up 4½-mile per hour speed (old style empty)	56 lbs.
Pull to keep up 4½-mile per hour speed (old style full).	66 lbs.
Pull to keep up 4½-mile per hr. speed (new style empty)	30 lbs.
Pull to keep up 4½-mile per hour speed (new style full).	38 lbs.

"The foregoing was for trains of 1 to 4 cars, but with a train of 20 cars the pull was 46 lbs. for old style cars and 26 lbs. for new style cars per short ton on a level track. The mine cars used had a wheel base of 3½ ft.; they weighed 2,140 to 2,415 lbs. empty and 7,885 to 9,000 lbs. loaded. The diameter of the wheels was 16 ins., and of axles 2⅛ ins. for old style car to 2½ ins. for new style car, with a steel journal 5¼ ins. long, well lubri-

cated in all cases, in fixed cast-iron boxes. The new style cars had better lubrication, the importance of which is well shown by the results of the tests. The track in the mine was level and in good condition. We know of no tests on car resistance of small cars that are as extensive and trustworthy as the foregoing."

Based upon these data, and upon the assumption that the resistance to traction is 40 lbs. per short ton, an 8-ton dinkey is capable of hauling the following loads, including the weight of the cars:

	Total Tons
Level track	70
1 per cent grade	46
2 per cent grade	33
3 per cent grade	26
4 per cent grade	21
5 per cent grade	17
6 per cent grade	14
8 per cent grade	10

Note: On a poor track not even as great loads as the above can be hauled.

Due to the accidents that frequently occur from the breaking in two of trains on steep grades, and from the running away of engines, it is advisable to avoid using grades of more than 6 per cent.

When heavily loaded, a dinkey travels 5 miles per hour on a straight track; but when lightly loaded, or on a down grade, it may run 9 miles an hour.

TABLE 127.

"Four coupled" saddle or side tank locomotives of any gauge from 30 ins. up, with 150 lbs. pressure, cost about as follows:

Cylinder and Stroke (Ins.)	Diameter of Driving Wheels (Ins.)	Wheel Base	Capacity of Water Tank (Gals.)	Weight (Tons)	Tractive Power	Price
5x10	24	2′ 9″	100	4½	1,322	$2,100
6x12	24	3′ 4″	110	6	2,286	2,200
7x12	26	3′ 4″	150	7	2,870	2,400
8x12	28	3′10″	200	10	3,483	2,650
9x14	30	4′ 6″	250	12	4,800	2,850
10x16	33	5′ 0″	400	15	6,100	3,150
12x16	33	6′ 0″	500	20	8,800	3,450

The load in tons of 2,240 lbs. which these engines will haul is as follows:

Cylinder and Stroke	On a Level	On Grade of ½%	1%	1½%	2%	2½%	3%
5x10	110	52	33	23	18	10	11
6x12	200	90	55	40	30	25	20
7x12	240	115	70	50	40	30	25
8x12	300	140	90	65	50	40	30
9x14	400	185	115	85	65	50	40
10x16	515	240	150	110	85	65	55
12x16	700	330	210	150	95	95	75

"Six coupled" switching locomotives with saddle or side tanks, of any gauge from 30 ins. up, with boiler pressure of 150 lbs., cost about as follows:

Cylinder and Stroke (Ins.)	Diameter of Driving Wheels (Ins.)	Wheel Base	Capacity of Water Tank (Gals.)	Weight (Tons)	Tractive Power	Price
7x10	24	4′10″	200	8	2,590	$2,750
8x12	26	5′ 5″	300	10	3,750	3,000
9x14	30	5′ 8″	350	13	4,800	3.250
9x16	33	6′ 9″	400	15	4,980	3,100
10x16	33	7′ 5″	450	18	6,150	3,700
12x18	37	8′ 1″	550	25	8,890	4,300

The load in tons which these engines will haul is about as follows:

Cylinder and Stroke	On a Level	On Grade of ½%	1%	1½%	2%	2½%	3%
7x10	240	110	70	50	38	30	25
8x12	355	165	105	75	59	47	39
9x14	455	210	135	95	75	60	50
9x16	475	220	140	100	78	62	51
10x16	590	270	170	125	95	76	63
12x18	855	395	250	180	135	110	90

Prices of Mogul locomotives, with the firebox between the middle and rear axles, and a boiler pressure of 160 lbs., complete with tender, are about as follows:

Cylinder and Stroke	Diam. of Drive Wheels (Ins.)	Wheel Base	Weight (Tons)	Tractive Power	Price
9x16	33	13′ 7″	14	5,340	$5,200
10x16	33	16′ 2″	17	6,590	5,500
11x18	37	17′ 5″	21	8,000	5,850
12x18	37	17′ 8″	24	9,520	6,250
13x18	37	17′10″	26	11,150	6,600
14x18	41	18′ 4″	29	11,700	6,900

The load in long tons which these engines will haul is about as follows:

Cylinder and Stroke	On a Level	On Grade of ½%	1%	1½%	2%	2½%	3%
9x16	425	195	120	80	60	45	35
10x16	525	235	145	100	75	55	45
11x16	650	295	180	125	95	70	55
12x18	750	340	210	145	110	85	65
13x18	850	385	235	165	125	95	75
14x18	940	430	265	185	140	105	85

Prices of Consolidated locomotives with long firebox over rear driving axle, complete with tender, are about as follows:

Cylinder and Stroke	Diam. of Drive Wheels (Ins.)	Wheel Base	Weight (Tons)	Tractive Power	Price
13x18	37	17′10″	29	11,150	$6,900
14x18	37	17′10″	32	12,930	7,300
15x20	37	11′ 9″	40	16,530	7,650
16x20	42	12′ 6″	42	16,570	8,050
17x20	42	13′ 0″	46	18,710	8,500
18x20	42	13′ 6″	50	20,980	8,800

The load in long tons which these engines are able to pull is about as follows:

Cylinder and Stroke	On a Level	On Grade of ½%	1%	1½%	2%	2½%	3%
13x18	925	420	260	185	135	105	85
14x18	1,040	470	290	205	155	120	95
15x20	1,330	605	375	265	200	155	125
16x20	1,425	645	400	280	210	165	135
17x20	1,560	710	440	310	230	180	145
18x20	1,715	780	480	340	255	200	160

Mr. Andrew Harper says that the life of a dinkey locomotive used on construction work is about 20 years. During that time it will need 2 or 3 sets of driving tires, and brasses.

Upon investigation of a very large number of locomotives upon the Great Northern, Northern Pacific and other railroads made by Mr. Gillette for a railway commission, the average life of a locomotive in railroad service is not far from 25 years, so that a fair average for depreciation may be 4 per cent if figured on the straight line formula. This does not represent the life of the different parts of the engine however.

On the Southern Pacific R. R. in six years there was an average of 49 locomotives out of 1,540 vacated per year or 3.2 per cent, which would establish the life of these locomotives at 31 years.

From July, 1907, to June, 1908, the cost of repairing locomotives for the Isthmian Canal Commission averaged about $81.45 per month per engine valued at about $7,500, or at a rate of 13 per cent per year.

Mr. R. Price Williams contributed a paper on the maintenance and renewal of average railway freight locomotives for the Institute of Civil Engineers of Great Britain, from which have been abstracted the following data on the life of various parts of locomotives:

Life in Train Miles	Life in Years	
10,000	½	India rubber pipe.
80,000	4	Painting.
100,000	5	Brass tubes, steel ferrules.
120,000	6	Crank axles, moulds, etc.
	7	Tires, pressure gauges, buffer planks, spindles, brass guards, wash out plugs, etc.
	10	Boiler, jcurnal boxes and caps, brasses, brass valves and syphons, firebox shell ends, tube plate and back firebox, copper recess plates, etc.
	15	Motion cylinders, reversing catchslide blocks, blast pipe, ash pan, outside and inside springs, spring links, spring pins, etc.
	17	Lubricator, shackle, buffer plank, chains.
	20	Clock boxes, balls and clocks, feed pipes, smoke-box door, etc.
	30	Plain axles, wheels, outside cranks, balance weights, slide bar brackets, slide bars, distance blocks, eccentric rods and straps, reversing gear lever and bracket, reversing rod shaft, quadrant and collar, connection rods and straps, bolts, framing, etc.
		TENDER.
	½	Brake blocks, hose packings etc.
	3	Painting, tires, bolts and nuts for tender.
	5	Oak plank.

"The standard value of an engine" (on the parabolic assumption) = ⅔ net cost, and the normal dilapidation ⅓ net cost. The life of locomotive tubes is a very important part of this question.

Mr. W. Garstang is authority for the statement that on the Big Four the average life of charcoal iron tubes was 75,000 miles

and on freight service 58,000 miles taken from engines with shallow fireboxes. When the fireboxes are deep the tubes accomplish 15 per cent more mileage. The data were obtained from No. 11 tubes weighing 2¾ lbs. per foot and it was the practice to continue to piece the best tubes until the weight was reduced 1.4 lbs. The average tube was pieced about 10 times before being condemned.

Mr. B. Haskell, of the Pere Marquette, believes that the life of locomotive tubes varies from 5 to 9 years, depending upon the quality of water used. The tubes worked an average of 15 months in service before being removed.

C. E. Queen's experience was to the effect that with alkali and incrusting solids in the water the tubes have failed in as short a time as 3 months, while with no scale and good water the tubes will last as long as 15 years.

Mr. D. Van Alstyne, of the Chicago Great Western, says that the average run on the road was 15 months, with average life of 7 to 8 years, steel tubes being limited to 6 months' service in one engine. Life of the deep firebox is longer than that of the shallow one.

Mr. Thos. Paxton, of the A., T. & S. F., does not know of a single feature of locomotive maintenance subject to wider variation than tubes. On the Middle Western division of that road, in freight service, it was difficult to get 18,000 miles per tube, while on the west end of the Chicago division 80,000 miles was obtained.

In the year 1907 the cost of maintenance of engines on several representative American railroads was as follows:

	Maintenance of Loco. per Year	Maintenance of Loco. per Train Mile	Maintenance of Loco. per Ton of Fuel Burned
Atchison	$2,875	12.50c	1.9c
Chi. & Alton	2,599	9.85	1.16
D., L. & W.	1,460	8.16	.731

These show an average of a little over $2,000 per locomotive per year, which is probably not far from 20 per cent of the original cost of each engine.

LOCOMOTIVE REPAIR COSTS, PANAMA.

The cost of repairs to locomotives, 286 in service, at Panama for the year ending June 30, 1910, was as follows per locomotive:

Item	Cost
Labor	$ 818
Material	316
Total	$1,134

The total cost of repairs during the 6 months ending June 30, 1910, for 31,955 days' service was an average of $6.94 per locomotive per day.

The following is a detailed statement of the cost of repairs

to engine No. 7, Dansville & Mt. Morris R. R., under the charge of the author. This engine had been operating for over a year with nothing but minor repairs and was no longer in fit condition for regular operation. These repairs include a pretty general overhauling and are about what would be necessary, aside from minor work that can be done by a roundhouse man, to keep it in fair condition for one year with a performance of about 15,000 miles. This is on a small railroad in the central part of New York. The tractive power of this engine was 11,100, the total weight 43 tons, and the weight on the drivers 29 tons.

4	New flgd. steel tires 57⅜-in. W. C. 5½x3½, 4,496 lbs @ 2¾ cents	$123.64
110	New steel tubes 2"x10'-6½", @ .10 ⅛-ft.	117.44
54	New safe ends for tubes, @ .08	4.32
170	New copper ferrules ¾x2x2⅛", 10 lbs. @ .22	3.96
176	New copper ferrules ¾x1⅞x2 5/32, 35 lbs. @ .23½	8.20
.42	New stay bolts 15/16x7, @ .08	3.36
8	New stay bolts, 1x7", @ .09	.72
5	New stay bolts 15/16" iron, 10 lbs. @ .05 1/10	.51
13	New 3/16" twist drills (broken drilling stay bolt holes)	1.30
2	New sheets 3/16" tank steel (tank bottom), 820 lbs. @ 1.96	16.17
1	New sheet 3/16" tank, 52 lbs. @ 2.20	1.14
2	New sheets C. R. jacket steel No. 22x28x72", 55 lbs @ 2.80	1.55
1	New C. I. driving box shoe and wedge, 60 lbs. @ .02½	1.50
	Babbitt metal for crossheads, 7½ lbs. @ .22	1.65
	Wrought iron, 72 lbs @ .02¼	1.62
	1" gas pipe, 6½ ft.	.21
1	Air hose complete with couplings	2.00
	2½" tank hose, 3 ft. @ .56	1.68
1	1" brass plug cock	.60
18	½x2" bolts with nuts and washers, .06	1.08
32	⅛-1½" bolts with nuts and washers, .01½	.48
21	⅜-1" bolts with nuts and washers, .01½	.32
2	¾x15" bolts with nuts and washers, .07	.14
4	¾x9" bolts with nuts and washers, .05	.20
6	¾" nuts	.13
6	¾" washers	.03
	Nails 20d., 1 lb. .03, 10d., dp 1 lb. .03	.06
	Rivets, ⅜x¾, 9 lbs.	.66
	Rivets, ⅜x⅞, 24 lbs.	1.43
	Rivets, ⅜x1, 2 lbs.	.10
	Rivets, ⅜x1½, 2 lbs	.10
2	16" square bastard files, @ .16	.32
1	16" half round bastard file	.18
6	Candles, @ .02½	.15
1	Hacksaw blade	.10
	Coke, 60 lbs.	.45
	½ Cord wood (heating tires)	1.00
	Wool waste, 12 lbs @ .04½	.54
	Tar paper, 38 ft.	.13
1	Ball lamp wick	.09
1	Sledge handle	.12
31	Sheets sand paper	.22
3	Sheets emery cloth	.07
	Powdered emery, 1½ lbs	.08
4	Pieces finished pine 2x6x19 ft.	2.16
6	Pieces finished pine 2x8x19 ft.	4.44
3	Pieces finished pine 1¾x10x9 ft.	1.17
1	Piece finished oak 2x9x13 ft.	1.30
1	Piece finished oak 2x8x10 ft.	.83
	Asphaltum, 1½ g.	.32
	Gloss black, ½ g.	.23

Drop black, 8 lbs	1.96
Cab green, ½ g	1.03
Turpentine, 1 g	.80
Linseed oil, ¼ g	.12
White lead, 2 lbs	.17
Red lead, 2 lbs	.24
Japan dryer, ¼ g	.23
Varnish, 1½ g	3.06
Filler, 5 lbs	.50
Russia jacket finish, 1 g	2.50
Black engine finish, 1½ g	3.03
Aluminum leaf	.20
Cylinder oil, 1 g	.41
Engine oil, 2½ g	.45
Black oil, 1 g	.15
Valve oil, 1 g	.14
Kerosene, 4½ g	.51
Benzine, 4½ g	.70
R. R. ticket for messenger	7.00
Total	$333.40

Applied labor, 1,540½ hours	$347.67	
Overhead 80 per cent labor	278.14	
		625.81
		$959.21
10 per cent		95.92
		$1,055.13
Credit for scrap, as follows:		
4 Steel tires, 2,450 lbs @ 12.50 C. T.	$13.67	
Tube and tube ends, 404 lbs. @ ½-cent lb.	2.02	
92 Second-hand tubes, 2"x10'-0", @ .10½	96.60	
Copper ferrules, 8 lbs. @ .10½ lb.	.84	
Stay bolts, 28 lbs @ ½-cent lb.	.14	
Tank steel, 674 lbs. @ ½-cent lb.	3.37	
C. I. shoe and wedge, 52 lbs. at ½-cent lb.	.26	
Brass plug cock, 1 lb.	.07	
		116.97
		$937.50

This included the following items of repair:

Examine and repair brasses.
Two second-hand wheel centers.
New 3½-in. tires.
Examine crank pins.
Take up side motion in driving boxes.
Turn engine truck tires
Examine driving box brasses.
Examine cylinders.
Examine valves.
Examine front end.
New studs for front door ring.
Cross head gibs babbitted.
Remove flues and copper both ends when replaced.
Examine stay bolts and drill tell-tale holes.
Examine boiler as per form No. 2, Public Service Com. and examine all corners of mud ring for leaks.
Examine flue sheet.
Test steam gauge and pops.
Take out ¾-in. air pump dry pipe and replace with 1-in.
Examine tender bottom, probably renew.
Stay sheets in tank gone, replaced.

LOCOMOTIVE CRANES

These machines are commonly steam driven, but may be arranged for driving by electricity. Steam cranes are usually equipped with double cylinder engines. The several motions of rotation, transfer on the track, moving the load and boom, are ordinarily accomplished by use of friction clutches; the engine then being of the non-reversing type. The boiler is placed behind the engine, thus serving to counterbalance the crane. The fuel and water tanks are also placed in the rear for the same purpose.

The following are the usual specifications:

Gauge of track	4 ft. 8½ ins. or 8 ft.
Boiler pressure	100 lbs. to 125 lbs.
Cut-off	6/10 to 8/10 of stroke
Revolutions per min. (engine)	80 to 200
Car wheels	24 in. diam.
Track speed	300 to 500 ft. per min.
Track power, level track	3 to 4 loaded cars
Slowing speed	4 revolutions per min.

Owing to the limitations of the counterweight the crane will raise its greatest load when working at its shortest radius. These cranes are generally able to pull several loaded cars on level track. The boiler should be large in order to demand only occasional attention from the operator.

One type of locomotive crane is made in two regular sizes; 10 and 20-tons at 10 ft. radius, without counterweight. These machines are made in 3-ft. 6-in., standard, and 8-ft. gauges, with 4 or 8 wheels. The manufacturers claim the following points of superiority.

Base of semi-steel casting, not of built-up members; turntable without a kingpin, but mounted on 20 to 30 dust-proof rollers; friction clutch; and, on the 8-wheeled machine, a reciprocating drive shaft which drives always on both trucks, while allowing them to pivot.

The price of these machines fitted with the standard 30-ft. radius boom is as follows:

			Lbs.
10-ton, 4 wheeled	$5,250	Shipping weight	60,000
10-ton, 8 wheeled	6,600	Shipping weight	80,000
20-ton, 4 wheeled	6,250	Shipping weight	80,000
20-ton, 8 wheeled	7,385	Shipping weight	95,000

Note: Working weight from 2 to 3 tons additional.

With lifting magnet and generator the cost is about $1,000 to $2,000 extra.

A special hoisting drum, by which a clam shell or orange peel bucket may be hoisted and opened at the same time, costs about $250 extra.

The 10-ton machine will hoist 5 tons at 20-ft. radius without counterweight, and 10 tons at 50-ft. radius with counterweight. The 20-ton machine will hoist 10 tons at 20-ft. radius without counterweight. The boilers and engines are of vertical type.

MACHINE TOOLS

LATHES.

Twenty-four-inch swing, 12-foot bed engine lathe, compound rest, power cross feed, steady rest, two face plates, friction countershaft, 2-in. hole through spindle and cabinet legs. This machine is made by the H. C. Fish Machine Works, Worcester, Mass., and weighs 5,500 lbs. A second-hand machine of this kind can be bought for $375.

Harrington Eng. Lathe: 25-in. swing, 12-ft. bed, compound

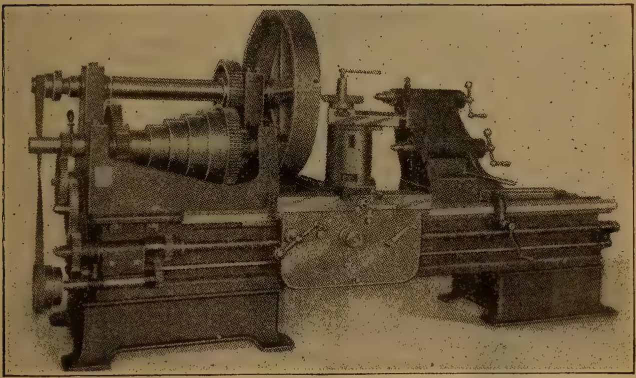


Fig. 175. McCabe's Patented "2-in-1" Double-Spindle Lathe. Small Size, 24-40-inch Swing.

rest, power cross feed, complete with countershaft and full equipment. Price, $375.

Pond engine lathe: 26-in. swing, 10-ft. bed, complete, $500.

McCabe's Patented 2-in-1 double spindle lathe: 24-in.-40-in. (See Fig. 175), bed 12-ft. long, that turns 5 ft. between centers, triple geared, complete with countershaft and full regular equipment. This machine has back gears, hand and power feed, automatic stop, quick return, wheel and lever feed. Spindle is counterbalanced. The table has vertical adjustment on column by means of handle operating gear in rack. Shafts are made of steel. Gears are cut two to one and cone has four steps, $3\frac{13}{16}$ inches to $8\frac{5}{16}$ inches diameter. Price $970.

A new 20-in. Davis Upright drill, with back gears, power feed, quick return and automatic stop. This weighs 700 lbs. and the price net is $90. Fig. 176.

A No. 2 Merriman Standard Bolt Cutter (Fig. 177), to thread

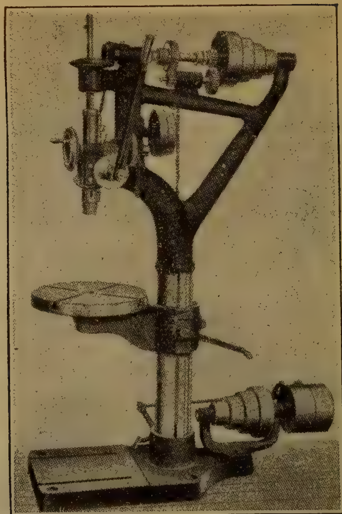


Fig. 176. 20-inch Davis Upright Drill.

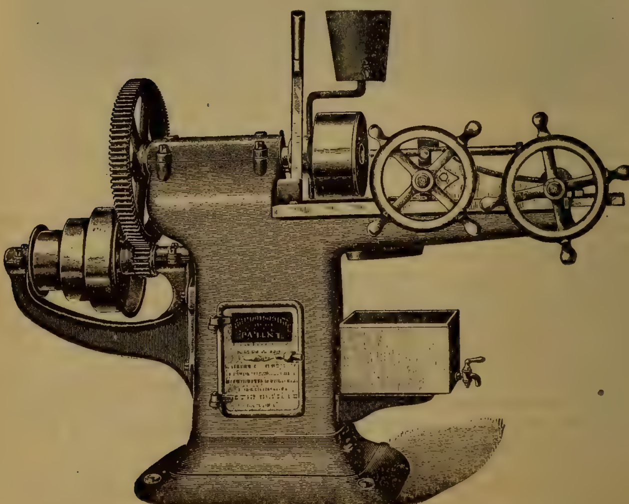


Fig. 177. Merriman Standard Bolt Cutter. Size No. 2. $1\frac{1}{2}$-inch Plain Machine.

bolts or tap nuts ⅜-in. to 1½-in. right or left hand, weighs 1,200 lbs. and can be bought second-hand for $175 net.

A single end-punch or shear weighs about 4,500 lbs. and will punch 1-in. hole through ½-in. plate or will shear 4-in. x ½-in. bars. A second-hand one will cost $300 net, while a new one would cost about $500.

A new Curtis & Curtis 4-in. pipe machine for hand or power takes from 1-in. to 4-in., right or left, weighs 525 lbs. net or 650 lbs. gross, and can be bought for $170 net.

A new No. 5 Champion three-geared ball bearing Upright, self-feed blacksmith post drill weighs 240 lbs. and costs $18.50 net.

A new circular saw, with wood table, weighs about 300 lbs. and costs $50 net.

A new 30-in. band saw with iron table weighs about 850 lbs. and costs $100 net.

Grindstone, machinist's: 30-in., heavy, mounted on an iron frame, with shield and water bucket, weighs about 1,500 lbs. and costs new about $50.

METALS

Miscellaneous Metals. Small lots of metal and metal products can be obtained from jobbers in New York at the following prices:

	Per Lb.
Bismuth	$2.25
Brass tubes, iron pipe sizes:	
½-in.	.19
¾ to 3-in.	.18
3½-in.	.19
4-in.	.20
Brass, sheets	.14½
Brass, rods	.14½
Solder, ¼ and ½, guaranteed	.24
Zinc, sheets	.08½
Manganese bronze rods	.16
Manganese bronze in crucible form	.14
Monel metal, ingot	.16

Old Metals. Miscellaneous lots of scrap metal amounting to about a ton can be sold to dealers in New York at about the following prices:

	Cents.
Copper, heavy and crucible	10.75 to 11.00
Copper, heavy and wire	10.50 to 10.75
Copper, light and bottoms	9.75 to 10.00
Brass, heavy	7.25 to 7.50
Brass, light	5.75 to 6.00
Heavy machine composition	9.75 to 10.00
Clean brass turnings	7.25 to 7.50
Composition turnings	8.25 to 8.50
Lead, heavy	3.75
Lead, tea	3.50
Zinc, scrap	4.00

Mineral Wool. New York City price that contractors or builders would pay for mineral wool is $21 per ton. The material is packed in bags which are charged extra at 12 cents each. For the middle west prices are as follows: Car load lots, f. o. b. factory, South Milwaukee, Wis., $12 per ton; less than car load lots, $14 per ton.

The above prices are all subject to change on short notice and are here given for purposes of rough comparison only.

MIXERS

Concrete mixers are usually divided into three classes: (1) Batch mixers, (2) Continuous mixers, and (3) Gravity mixers. In batch mixers the ingredients of the concrete in a proper amount or "batch" are placed in the machine, mixed, and discharged before another batch is placed in the mixer. In continuous mixing, the materials are allowed to enter the machine and the concrete to discharge continuously. Gravity mixers consist of especially constructed hoppers, troughs, or tubes so arranged that the ingredients flowing through them under the influence of gravity are mixed together into concrete.

1. Batch mixers are commonly of two types: One, that in which the drum is tilted in order to discharge the mixture; the other, that in which the drum is not tilted, but the concrete on being raised in the mixer by the mixing paddles drops on the inner end of a discharge chute which conveys it to wheelbarrows or other placing devices.

The following prices, etc., are those of a tilting mixer in which the drum, supported on horizontal axes, is tilted in order to discharge the concrete. The drum of this machine is formed of two truncated cones with their large ends joined and the concrete is mixed by means of steel plate deflectors:

	No. 0	No. 1	No. 2	No. 2½	No. 4	No. 5
Listed capacity (yds. per hour)	9	20	30	39	46	62
Horse power required....	4	6	8	10	15	19
Weight on skids with pulley	1,740	2,500	3,600	4,400	6,200	7,900
Weight on trucks with pulley or gears	3,200	3,650	4,750	5,500	7,400	
Weight on trucks with steam engine and boiler	3,750	5,600	7,200	8,600	11,400	
Weight on trucks with gasoline engine	4,000	5,100	7,400	9,300		
Price on skids with pulley	$300	$410	$ 525	$ 575	$ 720	$ 875
On skids with steam engine	415	540	690	765	935	1,135
On skids with engine and boiler	565	725	900	1,000	1,220	
On skids with gasoline engine	615	855	1,050	1,220		
On trucks with pulley...	350	480	610	665	820	
On trucks with steam engine	465	610	760	840	1,025	
On trucks with engine and boiler	615	780	965	1,085	1,315	
On trucks with gasoline engine	665	925	1,115	1,285		

Another type of tilting mixer is one in which the drum is supported on a frame and in discharging the frame is tilted, thereby tilting the drum. The following prices and capacities, etc., are those of a machine of this type whose drum is cubical in shape, and the mixing is done by the "folding" of the ingredients caused by this peculiar shape:

Size of mixer by numbers	Handy	No. 6.	No. 11.	No. 17.	No. 22.	No. 33.	No. 64.
Size of mixer by cu. ft., one batch	2½	6	11	17	22	33	64
Maximum capacity, cu. yds. per hour	5½	13	24	40	50	70	120
Ordinary capacity, cu. yds. per hour	3	8	15	25	30	45	75
Horse power, steam engine	1½	3	6	8	12	15	30
Horse power, boiler	2	4	8	10	15	18	35
Horse power, gasoline engine	2½	5	8	10	.....	.....	.....
Horse power, electric motor	2	4	7	10	15	20	35
Revolutions per minute of cube	24	20	18	17	16	15	14
Revolutions per minute or drive shaft	144	200	185	200	165	180	180
Inside length of cube	26	33¾	41½	47⅝	51⅝	57⅞	7′ 3″
Size of charging opening	12	13½	16	18½	20½	23½	2′ 2″
Size of discharge opening	10	11	13½	14¾	16	20	2′ 2″
Width of top of standard charging hopper	36	36	36	36	36	42	3′ 6″
Height from stand hopper to bottom of sills	40	42	47	55	61	70	6′ 9″
Length of mixer on short skids, overall	....	6′ 9″	8′ 0″	8′ 10″	10′ 2″	13′ 6″	15′ 4″
Length of mixer on long skids, overall	9′6″	12′ 0″	14′ 0″	17′ 0″	17′ ¾″	18′ 0″	
Length of mixer on trucks, overall	8′0″	12′ 9″	14′ 2″	18′ 3″	17′ 7¾″	18′ 6″	
Width of mixer on short or long skids, overall	4′7″	5′ 8″	7′ 0″	7′ 3″	8′ 3″	9′ 9″	12′ 2″
Width of mixer on trucks, overall	4′7″	5′ 10″	7′ 3″	8′ 1″	8′ 10″	10′ 8″	
Extra height when mounted on trucks	11″	17″	17″	17″	18″	19″	
Width of tire on truck wheels	2″	5″	6″	6″	6″	8″	
*Price, mixer only	$170	300	410	595	850	1,025	2,250
*Charging elevator, extra	200	250	300	375	450	500	....
*Trucks	35	50	80	100	120	130	....
Approximate Shipping Weights.							
On short skids, no power	1,000	2,300	3,100	5,400	7,500	9,300	18,000
On long skids, steam engine only	1,000	2,700	4,200	7,500	9,600	11,800	.....
On long skids, engine and boiler	....	3,800	5,800	9,300	11,600	14,300	.....
On long skids, gasoline engine	1,600	3,100	4,900	7,900	10,500	.....	.....
On long skids, electric motor	....	2,700	4,200	6,900	9,200	10,800	.....
On trucks, no power	1,300	3,000	5,100	6,800	9,800	12,000	.....
On trucks, engine only	1,400	3,400	6,100	8,500	11,500	15,000	.....
On trucks, engine and boiler	....	4,400	7,700	10,300	13,500	17,000	.....
On trucks, gasoline engine	2,000	3,800	6,800	8,900	13,000	.....	.....
On trucks, electric motor	....	3,400	5,800	7,800	11,300	14,000	.....
Extras.							
Charging elevator, comp	....	1,800	2,100	2,300	4,200	5,700	.....
Hoisting drum only (no cable)	....	670	670	670	1,264	1,264	.....

* Prices: Less 10 per cent, f. o. b. Chicago.

Two examples of the non-tilting type of batch mixer are given below.

Catalog Number.	No. 5.	No. 6.	No. 7.
Size of batch in yards	⅓	½	1
Listed capacity in yards	20	30	40
Horse power of engine	6	8	12
Horse power of boiler	7	10	15
Horse power of electric motor	7½	10	.....
Horse power of gasoline engine	6	9	.....
Weight on truck, engine and boiler	6,300	8,200	10,000
Weight on truck, gasoline engine	5,400	6,800	.....
Weight on truck, electric motor	5,100	6,200	.....
Weight on truck, engine only	5,100	6,200	8,000
Weight on truck with pulley	4.300	4,600	5.800
Weight on skids, engine only	4,600	5,600	7,300
Weight on skids with pulley	3,900	4,600	5,800
Weight of power loading skip	900	1,100	1,800
Price on trucks, engine and boiler	$740	$910	$1,150
Price on trucks, gasoline engine	765	945	1,215
Price on trucks, electric motor	765	945	1,170
Price on trucks, engine	645	730	875
Price on trucks with pulley	555	630	740
Price on skids with pulley	520	585	675
Price on skids, engine	605	700	810
Price of power loading skip	160	200	270

A No. 6 batch end discharge mixer of above make with reversible tractions, steam power, price complete $1,535, has a record of 20 cu. yd. per hour for 37 working days on street pavement work.

Catalog Number.	Number						
	7	10	14	21	28	40	80
Size of batch, cu. ft.	7	10	14	21	28	40	80
Capacity per hr. in yds.	7	10	14	21	28	40	80
H. P. of engine	4	6	6	8	12	20	35
H. P. of boiler	6	7	9	12	15	25	50
Weight on skids, pulley	1,500	1,600	2,400	3,500	4,500	6,700	13,000
Weight on skids, engine	2,100	2,450	3,600	5,200	6,500	9,800	18,900
Weight on engine and boiler	3,500	4,200	5,600	7,600	9,400	15,000	25,800
Weight on gasoline engine	2,900	2,300	4,300	6,500	8,100	.....	.....
Weight on motor	2,600	2,800	4,100	6,000	6,300	9,900	18,400
Extra weight of trucks	525	525	600	700	725	775	.....
Price on trucks, pulley	$325	$400	$460	$550	$600	$750	$1250
Price on trks., engine	$500	$600	$700	$845	$1005	$1350	$1900
Price engine and boiler	$670	$780	$940	$1180	$1400	$1800	$2550
Price gasoline engine	$695	$845	$980	$1185	$1300	.....	.....
Price motor	$700	$870	$920	$1135	$1250	$1760	$2500
Weight of batch hopper	230	260	300	450	500	570	1290
Price of batch hopper	$45	$50	$53	$56	$68	$75	$125
Price of pivot hopper	$220	$250	$265	$280	....	....	....
Water measuring tank	20	20	22	25	25	30	35

Above prices include trucks, except No. 40 and No. 80. Deduct $60.00 when trucks are omitted.

Special Machines	Steam	Electric	Gasoline
Type 1 street mixer No. 14, with loading skip	$1,600	$1,575	$1,650
Type 2 street mixer No. 14, with loading skip	.....	1,575	1,650
Combination mixer and hoist No. 21	1,800	1,750	1,800

VERY SMALL GASOLINE-DRIVEN MIXER.

This machine (Fig. 178) consists of a steel channel frame mounted on steel wheels. The drum is of very simple construction, the bottom being a semi-steel casting, and upper part sheet steel. The top of the drum is open, and the charging and dumping are performed through this opening, the drum tilting to the side as desired. The manufacturers state the output as 25 cu. yds. per day, mixed and placed with a gang of 6 men. The

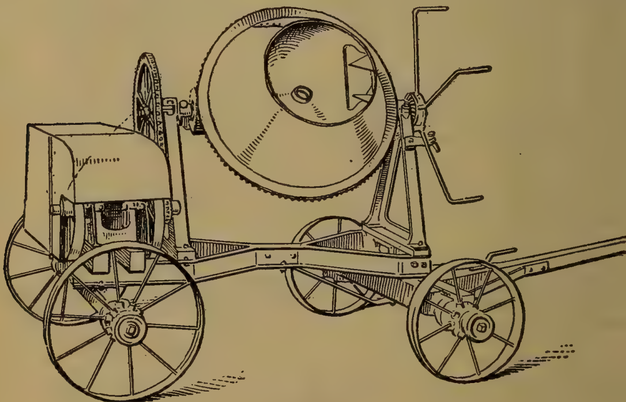


Fig. 178.

size of the batch is 3-4 feet. Weight of machine, complete, 1,250 lbs.; price, $194, f. o. b. factory in Iowa.

A few mixers are made for operation by hand or horse power. These are especially of use in sidewalk work or in any construction which demands well mixed concrete in small amounts and quantities.

Following are the details of hand operated mixers which are valuable on work where they can be placed directly over or alongside the forms.

Hand Mixer. 1. Drum is cylindrical, suspended in chains. Interior of drum is divided into chambers and the batch is mixed by being poured from one to another when the drum is rotated by two men. When the drum is rotated in a reversed direction the concrete is discharged. Weight 800 lbs.; capacity 3 cu. ft. per batch and 25 batches per hour; price $150, f. o. b. factory.

2. Drum is cubical, carried directly on the axle, but so arranged that it may be thrown out of gear and operated as a cart. A batch is 2.7 cu. ft., and the manufacturers claim a capacity of 15 cu. yds. per 8-hour day with two operators. The weight is 400 lbs. and price $100, f. o. b. factory.

Continuous Mixers are constructed in two general forms. One

in which the ingredients are placed in hoppers and automatically fed in proper quantities to the mixing trough, the other in which the materials are shoveled or otherwise placed directly into the mixing drum.

The two examples given below are of the first form, but can also be furnished without automatic feeding devices at a slightly lower charge.

TABLE 127—CONTINUOUS MIXERS.

	Listed Capacity per Hr. (Cu. Yds.)	Price	Equipment	Weight (Lbs.)
No. 1 Two hoppers	6	$ 650	Gasoline engine, 5 H. P	3,600
		775	Steam engine, 5 H. P. and 6 H. P. boiler....	5,050
		775	5 H. P. electric motor..	3,240
No. 2 Three hoppers	7	745	5 H. P. gasoline engine.	3,800
		765	5 H. P. steam engine and 6 H. P. boiler....	5,250
		785	7½ H. P. electric motor	3,625
No. 2½ Three hoppers	12	965	9 H. P. gasoline engine	6,150
		965	6 H. P. steam engine and 7 H. P. boiler...	7,145
		990	7½ H. P. electric motor	5,385
No. 3 Three hoppers	16	1,235	8 H. P. steam engine and 10 H. P. boiler..	9,160
		1,260	10 H. P. electric motor	7,160
		1,325	With steam traction..	9,950
No. 4 Three hoppers	25	1,575	12 H. P. engine and 15 H. P. boiler..........	13,500
		1,710	With steam traction..	15,000

	Listed Capacity per Hr. (Cu. Yds.)	Price	Equipment	Weight (Lbs.)
3 H. P. engine 4 H. P. boiler	12 to 15	$ 800	On truck with boiler and engine..........	3,000
3½ H. P. engine	12 to 15	675	On truck with gasoline engine (pump $25 extra)................	2,500
6 H. P. engine	15 to 18	1,050	On truck with gasoline engine	2,700

COMPARISON OF RENTED AND OWNED CONCRETE MIXERS.

From *Engineering Record,* New York.

The figures in the accompanying tables have been compiled from the records of the Aberthaw Construction Company, of Boston, who ran a ledger account for each mixer. The oldest mixer is nearly seven years old. The original cost, repairs, and other expenditures are charged against the machine and it is credited with so much per day for the elapsed time it is on a job. This rental credit is based as nearly as possible on what it would cost to rent this plant instead of buying it outright.

Interest is figured at the rate of 6 per cent per annum on the original purchase price and compounded annually Jan. 1. All the figures are brought up to Jan. 1, 1910, and the inventory value of the machines taken at this date. The yardage is a very close approximation of the actual amount mixed.

Comparison of the owned and rented plant costs for each mixer shows that there is very little saving by owning the mixers when they are over 5 years of age, as in the cases of Nos. 2 and 3. In fact, No. 2 shows a small balance in favor of renting. On the other hand, No. 6, a comparatively new machine, working on large yardage, shows a less economy than No. 3. Mixer 4, owned a little less than 4 years, rented 62.7 per cent of the time and working on comparatively small yardage, such as reinforced concrete buildings, shows the largest economy from an owner's standpoint.

I.—FIRST COST AND REPAIRS FOR FOUR MIXERS.

(Actually Owned)

Mixer No.	2	3	4	6	Totals
Date of purchase.	8/18/03	6/10/04	6/7/06	6/5/07	
Original cost	$ 625.00	$ 975.00	$ 975.00	$ 935.00	$3,510.00
Interest at 6% to Jan. 1, 1910....	281.51	368.90	220.57	153.37	1,024.35
Repairs to Jan. 1, 1910	941.87	350.29	216.43	437.01	1,945.60
Total cost to Jan. 1, 1910	1,848.38	1,694.19	1,412.00	1,525.38	6,479.95
Inventory value Jan. 1, 1910....	125.00	325.00	400.00	500.00	1,350.00
Net cost to Jan. 1, 1910.........	1,723.38	1,369.19	1,012.00	1,025.38	5,129.95
Total yds. mixed.	12,350	15,500	10,500	19,000	57,350
Plant cost per yd..	$0.1395	$0.0883	$0.0964	$0.0540	$0.0894

II.—RENTAL CREDITS FOR FOUR MIXERS.

Mixer No.	2	3	4	6	Totals
Days owned to Jan. 1, 1910....	2,325	2,029	1,302	936	6,595
Days rented to Jan. 1, 1910....	827	718	816	536	2.997
Per cent of days rented	28.1	28.3	62.7	57	45.4
Rental rate per day	$2.00	$2.25	$2.25	$2.25	....
Total rental to Jan. 1	$1,655.00	$1,616.25	$1,836.25	$1,204.50	$6,311.00
Total yds. mixed.	12,350	15,500	10,500	19,000	57,350
Plant cost per yd.	$0.1340	$0.1042	$0.1748	$0.0634	$0.1100

III.—COMPARISON OF OWNED AND RENTED PLANTS.

Mixer No.	2	3	4	6	Totals
Plant cost per yd., Table 1........	$0.1395	$0.0833	$0.0964	$0.0540	$0.0894
Plant cost per yd., Table 2........	0.1340	0.1048	0.1748	0.0634	0.1100
Per cent saving by owning plant, based on rental cost	4.1	15.25	44.8	14.7	18.72

The cost of unloading and placing in condition for work averages about $65 to $75 per mixer.

Gravity Mixers. The most common form of gravity mixers consists of two or four small hoppers (depending upon the size of the mixer) set upon a frame support, which latter also carries a platform on which the men are stationed to load the materials into the hoppers. Below these top hoppers three large hoppers are set, one below another. To operate the mixer after the top hoppers have been charged the gates of these are opened,

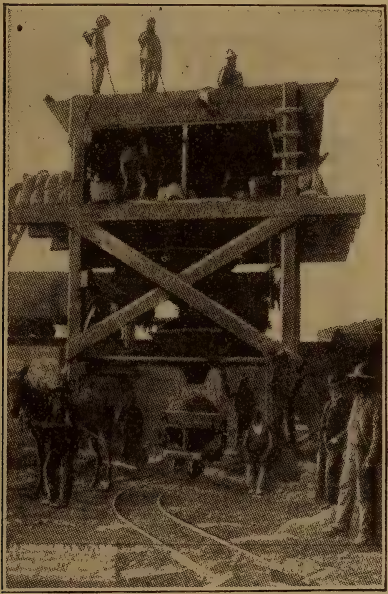


Fig. 179. Showing an Arrangement of the Hains Concrete Mixer.

and material allowed to pass into the hopper below, where it is caught and held until this hopper is full, upon which the gates are opened and the material allowed to flow into the next lower hopper and so on until the concrete is received in the bottom hopper ready to be taken to the forms. This is properly a batch mixer, but the charging is carried on while the material is being mixed in the lower hoppers.

Only the metallic parts of this mixer, that is, the hoppers, chutes, gates, etc., and not the wooden framework, are furnished by the manufacturer.

Stationary Gravity Concrete Mixer. (Figs. 179, 180) Small size, capacity ¾ cu. yd. per batch, weight of metallic parts 2,840 lbs. Price, f. o. b. nearest station, $1,250.

Medium size, capacity 1½ cu. yd. per batch, weight of metallic parts 7,060 lbs. Price $1,400.

This type of mixer is also made portable (Fig. 181) and is

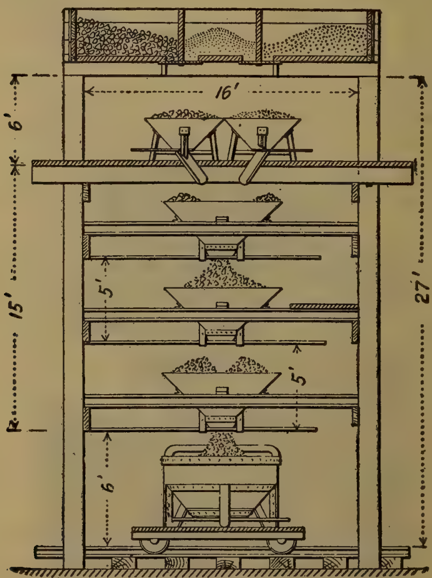


Fig. 180.

operated by being raised with a derrick or elevator. The capacity of this small machine is about six cu. yds. per hour and ⅔ cu. yds. per batch. Weight 1,400 lbs., complete. Minimum height 12 ft. Price $550.

Output of Mixers. On well organized work a batch every two minutes, or 30 batches an hour, should be averaged. The real capacity of any mixer is usually determined by the speed with which the materials are delivered and taken away. In regard to mixer efficiency I can do no better than to quote from Gillette and Hill's "Concrete Construction": "The most efficient mixer is the one that gives the maximum product of standard quality at the least cost for production."

Mr. Chas. R. Gow, in a very complete paper read before the Boston Society of Civil Engineers, gives the cost of concrete crushing, mixing and placing plant.

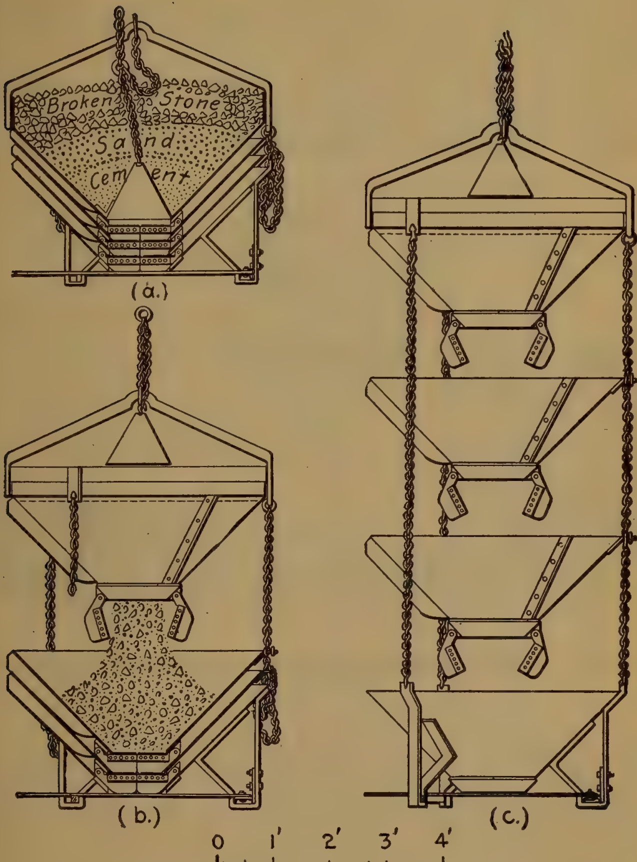


Fig. 181. Portable Gravity Mixer.

This plant is shown in Fig. 182. The engine used was a 40 H. P. gasoline engine, but a 25 H. P. was all that the plant required. The crusher was a 10x20 in. jaw crusher which was fed by hand with stone dumped by teams on the crusher platform. The gravel and sand were dumped on the platform and shoveled on to an inclined grating which allowed the sand to drop into a 34-ft. bucket elevator, while the larger gravel was chuted to the crusher and thence to the elevator. The rotary screen separated the sand and stone into bins from which it dropped to a measuring hopper and thence to a skip car. This car was provided with

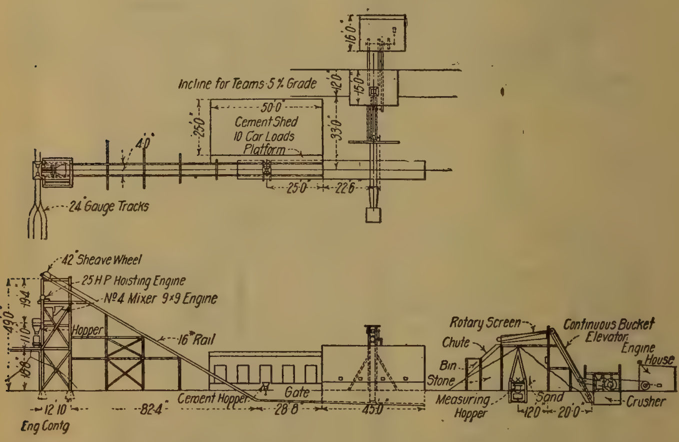


Fig. 182. Plan of Screening, Crushing and Mixing Plant, Springfield Filters.

the proper amount of cement from a hopper and was hoisted up the incline and its contents automatically dumped into a one-yard mixer which discharged into a one-yard hoisting bucket on a flat car. These cars, which had room for one empty and one full bucket, were drawn by cables along a track to the placing derricks, of which there were two, with 75-ft. guyed masts and 80-ft. booms.

This plant cost about $5,000 at the factory, $600 for freight and transportation and $3,900 to install and maintain in working condition; total cost, therefore, $9,500. It was capable of mixing 60 cu. yds. per hour, but actually mixed less than 15. The total number of yards of concrete placed was 13,282, which was less than the smallest amount necessary to make the use of such a plant economical.

Cost per cubic yard for crushing, mixing and placing:

	Per Cu. Yd.	
Transporting to Work:		
Freight of plant to Westfield	$0.0139	
Cost of unloading plant from cars	0.0148	
Cost of teaming plant to work	0.0161	
Total cost of landing on job		$0.0448
Final Removal of Plant:		
Cost of labor dismantling and loading	$0.0302	
Cost of teaming to railroad	0.0100	
Cost of freight returning	0.0043	
Total cost of removing plant		0.0445
Erecting and Maintaining Crusher and Concrete Plant:		
Cost of labor	$0.1725	
Cost of materials and supplies	0.1139	
Cost of miscellaneous teaming	0.0054	
Total cost of erection and maintenance of plant		0.2918
Cement Storehouse, 50 Ft. by 25 Ft.:		
Cost of materials used	$0.0205	
Cost of labor building	0.0120	
Total cost of cement house		0.0325
Erecting, Moving and Removing Derricks and Hoisters:		
Cost of labor	$0.1008	
Cost of miscellaneous supplies	0.0033	
Cost of miscellaneous teaming	0.0011	
Total cost of derricks		0.1052
Depreciation on Plant:		
Cost of depreciation on concrete plant	$0.1003	
Cost of depreciation on crusher plant	0.1370	
Total depreciation		0.1052
Coal and Oil Used in Mixing and in Operating Derricks:		
Cost of coal	$0.1222	
Cost of oil	0.0110	
Total cost		0.1332
Grand total cost of crusher and concrete plant		$0.8893

A large portable plant for crushing, mixing and placing concrete on the Catskill Aqueduct is described in *Engineering and Contracting,* Vol. XXXIV, No. 23. This plant was designed to build 30 lineal feet of aqueduct per day, but improvements and efficiency of the crew increased the capacity to 60 feet per day. The section on which this plant was operated was about 1½ miles long and the cross section of the aqueduct was of the flat base type, of interior dimensions of 17 ft. x 17½ ft. and walls from 12 to 24 in. in thickness.

The plant consisted of two principal parts, the first for crushing and mixing and the second for handling forms and concrete. The first part consisted of a steel frame work mounted on two 60-ft. steel flat cars placed side by side and bolted together. A gyratory crusher with bucket conveyor and revolving screen crushed the material and deposited it in a 20-yd. sand bin and a 40-yd. stone bin. These bins discharged into a Hains mixer and

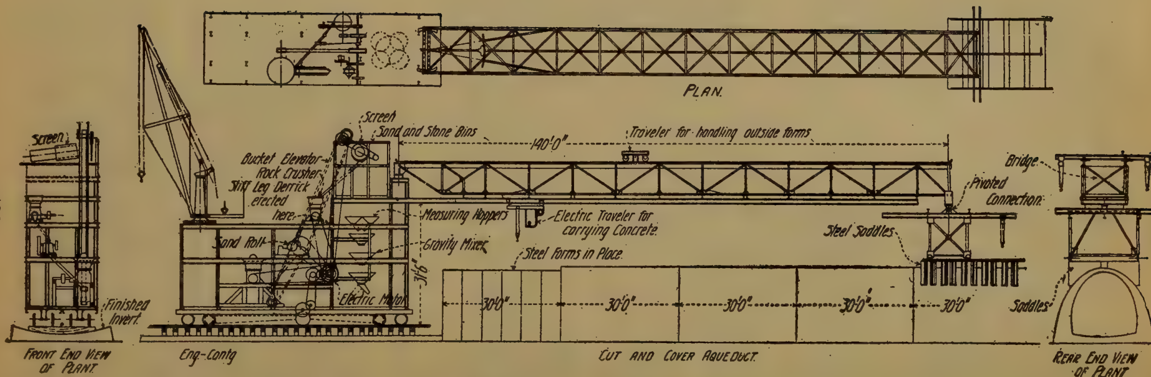


Fig. 183. General Plans Showing Elevation, Plan and End Sections of Portable Plant.

the concrete was picked up by an electric hoist in Hains buckets and conveyed to the forms. That part of the plant used in placing concrete and handling the outside forms consisted of a two-truss steel bridge 140 feet long, upon which traveled the several hoists. The concrete bucket hoist was suspended beneath the bridge and equipped with one 11 H. P. motor for hoisting and two propelling motors of 3 H. P. each. On top of the bridge was a traveler equipped with two 5 H. P. motors and overhanging arms for handling the forms. At the rear support was a chain hoist with a 5 H. P. motor for moving ahead the saddles which supported that end of the bridge. Steel collapsible forms were used and were shifted by a 30 H. P. motor-driven carriage. Materials for the crusher were handled by two derricks. All the plant with the exception of a small steam boiler used for cleaning concrete surfaces was operated with a high tension current supplied by a public service corporation. This plant is shown in Fig. 183. It cost about $30,000, and since it was built, nearly $10,000 was spent in changes and repairs. The plant worked well, but had only about 30,000 yards of concrete to place. It is doubtful whether such an equipment pays on a job of this size.

Lieutenant L. M. Adams, Corps of Engineers, U. S. A., in "Professional Memoirs" for January-March, 1911, describes a mixing and handling plant mounted on a barge for use in concrete work in locks, dams, etc. This plant is supplied with sand and gravel from barges alongside and the concrete is removed from it by a derrick set up on the forms or on a boat adjacent. The general scheme is shown in Fig. 184. The cost of such a plant is as follows:

Hull of barge	$ 4,000.00
Coal, sand (20 cu. yd.) and gravel (40 cu. yd.) bins	600.00
Boiler house and cement shed (1,000 barrels)	300.00
Derrick (55 ft. boom) complete with (8½x10 tandem drum) hoist, two duplicate boilers (each 30 H. P.), 8 strand 19-wire plow steel rope	3,300.00
1½-yard clam shell bucket	600.00
Mixer, complete	1,300.00
Cement car (6 bags) and hoist	400.00
Total	$10,500.00

Labor cost of operation per 8-hour day shift	$16.20
Coal to furnish 40 H. P. per shift	⅔ ton
Capacity, twenty 1½ cubic yard batches per 24 hours	30 yds.

Mr. H. P. Gillette in his Handbook of Cost Data describes a mixing plant used in building a concrete retaining wall. A batch mixer was used, the concrete being delivered by a cableway of 400′ span. The broken stone and sand were delivered near the work in hopper-bottom cars which were dumped through a trestle onto a plank floor. The material was loaded by hand into one-horse dump carts and hauled 900 ft. to the mixer platform. This platform was 24x24 ft. and 5 ft. high with a plank approach 40 ft. long and contained a total of 7,500 ft. B. M. After mixing,

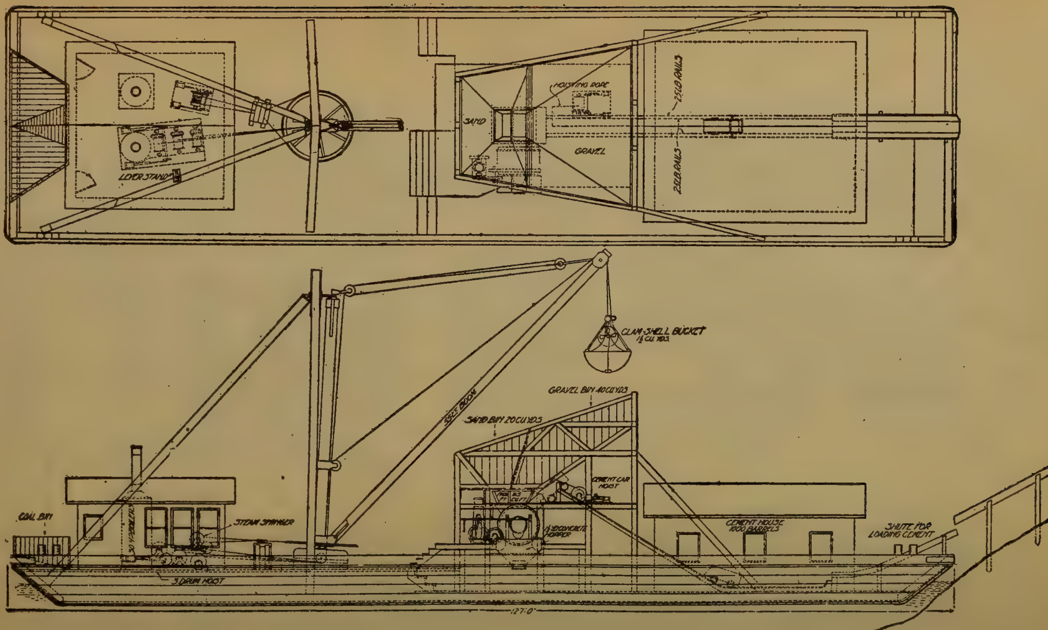


Fig. 184. General Plan of Floating Concrete Mixing and Handling Plant.

the concrete was dumped into iron buckets holding 14 cubic feet water measure, making about one-half cubic yard in a batch. The buckets were hooked onto the cableway and conveyed to the wall. Steam for running the mixer was taken from the same boiler that supplied the cableway engine. The average output of this plant was 100 cubic yards of concrete per 10-hour day at a cost for labor and coal of $1.07 per cubic yard. The plant had to be moved once per each 355 ft. of wall, 16 ft. high. This took two days and cost $100, or about 10 cents per cubic yard.

In an article by Mr. Wm. G. Fargo, of Jackson, Mich., in the proceedings of the Michigan Engineering Society, several types of concrete handling plants are described. Mr. Fargo considers that on work requiring the placing of 1,000 cubic yards of concrete or over, it is usually cheapest to install a plant for handling the materials. The wheelbarrow, on large concrete works, should seldom be used. The tip car with roller bearings will enable one man to push, on a level track, from 5 to 8 times a wheelbarrow load of concrete. Wagons or cars for bringing materials to the mixer may be drawn by teams on grades of 2 per cent, and by locomotives on grades of 4 or 5 per cent. Steeper grades will require cable haulage. On long retaining walls or dams the cableway is especially valuable. A cableway of 800-ft. span, capable of handling a yard of concrete, will cost complete with boiler, hoist and stationary towers 45 ft. high, from $4,500 to $5,000, and for the movable towers about $1,000 more.

Such a plant should be capable of handling 20 cubic yards per hour. Where the area is wide more cableways are necessary, but if not too wide derricks may economically rehandle the load. On work where the total width is a large fraction of the length and where other conditions are favorable the trestle and car plant may be much cheaper than the cableway. When the distance from the mixers to further boundary is less than 500 ft. this is especially true. The following figures give the cost of a car plant having a capacity of 200 yards per day with length of 500 ft. out from the mixers.

Trestle—Double track, 24-in. guage, 6 ft. between centers of tracks; 6-in.x8-in. stringers, 22 or 24 ft. long; 2-in.x6-in. ties, 2-ft. 6-in. centers, 2-in.x12-in. running boards between rails, 12-lb. rail.

Trestle legs (30 ft. average length) of green poles at 5 cents per ft., will cost complete about $1.50 per lineal ft. of double track, or for the 150 ft.:

At $1.50, erected	$225.00
Five split switches, with spring bridles, at $18.00	90.00
Two iron turntables, at $30.00	60.00
Three ⅔-yd. steel tip cars, with roller bearings	190.00
	$565.00

This outfit, with repairs and renewals amounting to 10 per cent, should be good for five seasons' work. If labor costs $1.75 per day the cost of handling 200 cu. yds. of concrete would be 4⅜

cents per yard. This, according to Mr. Fargo, would be a saving of about 5¾ cents per cu. yd.

GROUT MIXER.

The machine illustrated in Fig. 185 is furnished in two sizes: "Low pressure" for work up to 150 lbs. per square inch, and "high

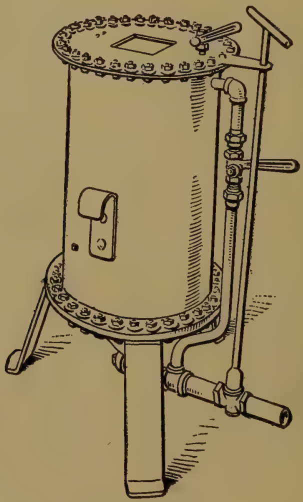


Fig. 185.

pressure" for work up to 300 lbs. per square inch. The machine is operated by compressed air, but the manufacturers do not furnish a compressor. The prices are $175 and $250, f. o. b. works or Hoboken, N. J.

NAILS

Prices. The net prices in Chicago for nails in quantities are as follows:

Shingle Nails.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
3d	1¼ in. No. 13	380	$2.58
4d	1½ in. No. 12	256	2.43

Galvanized Shingle Nails.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
3d	1¼ in. No. 13	429	$3.08
4d	1½ in. No. 12	274	2.93

Barbed Roofing Nails.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
¾ in. barb R. F..	¾ in. No. 13	648	$2.88
⅞ in. barb R. F..	⅞ in. No. 12	413	2.78
1 in. barb R. F..	1 in. No. 12	384	2.73
1⅛ in. barb R. F..	1⅛ in. No. 12	339	2.73
1¼ in. barb R. F..	1¼ in. No. 11	231	2.68
1½ in. barb R. F..	1½ in. No. 10	154	2.58
2 in. barb R. F..	2 in. No. 9	103	2.48
1¾ in. barb R. F..	1¾ in. No. 10	151	2.58

Common Steel Wire Nails in Kegs of 100 Lbs. Each.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
2d	1 in. No. 15	900	$2.83
3d	1¼ in. No. 14	615	2.58
4d	1½ in. No. 13	322	2.43
5d	1¾ in. No. 12	254	2.43
6d	2 in. No. 12	200	2.33
7d	2¼ in. No. 11	154	2.33
8d	2½ in. No. 10	106	2.23
9d	2¾ in. No. 10	85	2.23
10d	3 in. No. 9	74	2.18
12d	3¼ in. No. 9	57	2.18
16d	3½ in. No. 8	46	2.18
20d	4 in. No. 6	29	2.13
30d	4½ in. No. 5	23	2.13
40d	5 in. No. 4	18	2.13
50d	5½ in. No. 3	13½	2.13
60d	6 in. No. 2	10½	2.13

Coated nails suitable for either machine or hand driving are sold at the same price as the above.

Casing Nails.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
2d	1 in. No. 16	1,140	$3.13
3d	1¼ in. No. 15	675	2.83
4d	1½ in. No. 15	567	2.63
6d	2 in. No. 13	260	2.48
8d	2½ in. No. 12	160	2.38
10d	3 in. No. 11	108	2.28
16d	3½ in. No. 10	69	2.28
20d	4 in. No. 9	50	2.28

Finishing Nails.

Size	Standard Gage and Length	Approx. No. in 1 Lb.	Price per 100 Lbs.
2d	1 in. No. 17	1,558	$3.28
3d	1¼ in. No. 16	884	2.98
4d	1½ in. No. 16	767	2.78
6d	2 in. No. 14	359	2.58
8d	2½ in. No. 13	214	2.48
10d	3 in. No. 12	134	2.38
16d	3½ in. No. 11	91	2.38
20d	4 in. No. 10	61	2.38

Standard railroad spikes....................................$1.70
Standard track bolts, base.................................. 2.15

Pittsburg quotations on spikes based on $1.60 per keg are as follows:

Railroad Spikes.

4½, 5 and 5½x$\frac{9}{16}$		$1.60
3, 3½, 4, 4½ and 5x½	Extra	.10
3½, 4 and 4½x$\frac{7}{16}$	Extra	.20
3, 3½, 4 and 4½x⅜	Extra	.30
2½x⅜	Extra	.40
2½, 3 and 3½x$\frac{5}{16}$	Extra	.60
2x$\frac{5}{16}$	Extra	.80

Boat Spikes.

¾ in. square, 12 to 24 in. long	Extra	.15
⅝ in. square, 8 to 16 in. long	Extra	.15
½ in. square, 6 to 16 in. long	Extra	.15
$\frac{7}{16}$ in. square, 6 to 12 in. long	Extra	.20
⅜ in. square, 4 to 12 in. long	Extra	.30
$\frac{5}{16}$ in. square, 4 to 8 in. long	Extra	.45
¼ in. square, 4 to 8 in. long	Extra	.75
¼ in. square, 3 to 3½ in. long	Extra	1.00

⅜ and $\frac{5}{16}$ shorter than 4 in., ¼ cent extra.

OIL

Lubricating Oils. The following prices are quotations on 5-bbl. lots:

	Cts. per Gal.
*Cylinder, dark	20 to 32
*Cylinder, steam, refined	14 to 25
Neutral Oils, Filtered:	
Stainless white, 32 to 34 gravity	28 to 29
Lemons, 33 to 34 gravity	17 to 22
Dark, 32 gravity	15 to 20
Crank cast oil	15 to 20
Fuel oil	4 to 10
Kerosene	11 to 20
Albany grease, per lb., about	10

* Prices according to test.

PAINTS AND OILS

New York City quotations during the year 1913 were as follows:

Linseed Oil.

City raw, 5 bbls. or more	$0.46	to	$0.52
Out of town raw, 5 bbls. or more	.45	to	.51

Boiled oil—1 cent in advance of price of raw oil.
Refined oil—2 cents in advance of price of raw oil.

Turpentine.

5 bbls. or more	$0.41	to	$0.47

White Lead.

100, 200 and 500 lb. kegs	$0.0725	to	$0.08
25 and 50 lb. kegs	.0775	to	.085

Red Lead and Litharge.

100 lb. kegs	$0.07	to	$0.08

Colors in Oil.

Lamp black	$0.12	to	$0.14
Chinese blue	.36	to	.46
Prussian blue	.32	to	.36
Van Dyke brown	.11	to	.14
Chrome green	.12	to	.16
Raw or burnt sienna	.12	to	.15
Raw or burnt umber	.11	to	.14

Paint on an average covers about 600 sq. ft. per gal. The main cost of painting lies in the labor of preparing the surface and applying, not in the cost of the paint. A rough surface takes more labor and a greater quantity of material. Paint should be tested for flashing, cracking, brushing qualities, elasticity, breaking, blisters and acid and alkaline qualities. It is usually a mistake to add extra dryer to prepared paints, as the expected results do not necessarily ensue. Double boiled oil with a dryer is often used for shop coat work. In shop coat work have all the surfaces thoroughly cleaned of mineral oils, as otherwise they will not dry and it is necessary to have a quick drying paint for this purpose.

The cost of giving structural steel a shop coat is $1.00 per ton up, and one coat after erection costs about $2.00.

PAPER

Building Paper. Quotations in New York during 1913 were as follows:

	Per roll of 500 sq. ft.
Rosin sided sheathing, 20 lb.	$0.28
Rosin sided sheathing, 30 lb.	.43
Rosin sized sheathing, 40 lb.	.58

Rubber Roofing.

	Per roll of 108 sq. ft.
1 ply, 35 lb.	$0.90
2 ply, 45 lb.	1.10
3 ply, 55 lb.	1.30

Tarred felt was $1.45 per 100 lb. in 1, 2 and 3 ply. Slaters felt was 60 cts. per roll.

PAILS

Tar Pails. Net prices at Chicago for tar pails are as follows:

	Each.
Pay-off pail	$4.50
Pay-off pail spouts for wood or stone	.90
3-way spouts for brick or stone	4.50
Carrying pail	2.70

Prices. Net prices at Chicago for various kinds of pails are as follows:

Galvanized, Regular.

Capacity, Qts.	Weight, per Dozen, Lbs.	Per Doz.
10	24	$2.05
12	38	2.30
14	30	2.75

Galvanized, Extra Heavy.

Capacity, Qts.	Weight, per Dozen, Lbs.	Per Doz.
12	39	$3.55
14	33	3.85
16	37	4.45

Galvanized cement pails with double braced bottom, extra heavy, of 14 quart capacity, can be bought at $8 per dozen. Heavy oak pails with iron bails, 14 quart capacity, bring a net price of 55 cts. each or $5.50 per dozen. Common pine pails, 2-hoop, cost $2.50 per dozen; with three hoops they cost $3 per dozen.

PAULINS

Canvas coverings for protecting cement, brick, machinery, etc., from the weather.

Size, Feet.	8 Oz. Duck.	10 Oz. Duck.	12 Oz. Duck.
5½ x 9	$ 1.00	$ 1.25	$ 1.50
7 x12	1.65	2.10	2.50
10 x16	3.20	4.00	4.80
12 x16	3.85	4.80	5.75
14 x20	5.60	7.00	8.40
18 x20	7.20	9.00	10.80
20 x30	12.00	15.00	18.00
24 x50	24.00	30.00	36.00

PAVING EQUIPMENT

PETROLITHIC CONSTRUCTION EQUIPMENT.

The Petrolithic System is designed to produce stable and economic earth, sand-clay, gravel and macadam roads by uniformly compacting them from the bottom up, and also to construct solid foundations for asphalt, concrete, brick and block pavements. For further information on this type of construction we refer to *Engineering and Contracting*, June 9, 1909.

The following is a list with weights and prices of the special implements made by the Petrolithic Company.

Tamping Roller: This machine is designed to imitate the compacting action of sheep's feet, and of the small ended tamper

Fig. 186. Building Asphaltic Gravel Street in Whittier, Cal.

commonly used to tamp the earth around posts. It will compact any thickness from two to ten inches, but it is not usually economical to compact a greater thickness than four to six inches at one operation. The material is put into condition for tamping by puddling with water or some other liquid, but care must be taken to use the proper amount of liquid in order that the mixture may be of the proper consistency. The feet of the roller are nine inches long. The body is composed of two wooden drums with a tamping width of six feet. It is usually drawn by four horses. This machine is also very useful in compacting earth embankments. Weight of machine 4,800 pounds, price $150. Another type is illustrated in Fig. 186.

Rooter-Scarifier, or Gang Road Rooter: Fig. 187. This machine is a combination of plow, rooter and scarifier. It is commonly operated by a traction engine. Weight of machine 4,000 pounds, price $450.

Spike Disc Scarifier: Fig. 188. This implement is constructed and operated on the principle of a disc harrow, but having

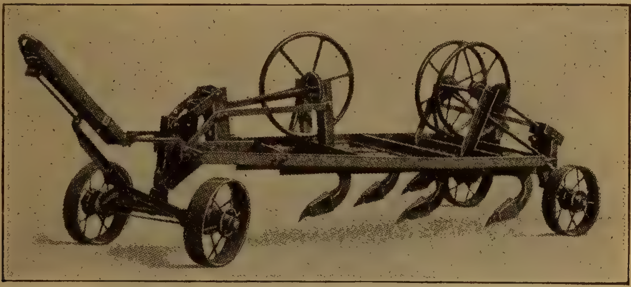


Fig. 187. Petrolithic Gang Rooter. Combined Plow, Rooter and Scarifier for Road or Other Heavy Work.

peculiarly shaped spikes instead of cutting discs. It is usually drawn by four horses. When used in connection with the rooter, its particular function is to break up and pulverize the clods.

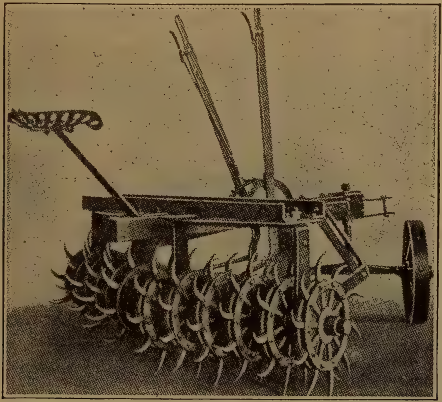


Fig. 188. Petrolithic Rotary or Spike Disc Scarifier.

It is also used to scarify. Weight of machine 1,300 pounds, price $175.

Road Cultivator: Fig. 189. This machine is designed to thoroughly mix the dry and liquid materials. Weight of machine 700 pounds, price $80.

Road Asphalt Distributor: Fig. 190. This is a trailing attachment operating on its own wheels, which may be readily attached

and detached from the tank wagon. The fluid is distributed under the force of gravity. It covers 8 ft. in width. Weight of machine 1,200 pounds, price $275.

Asphalt Distributor: This implement fastens directly on the

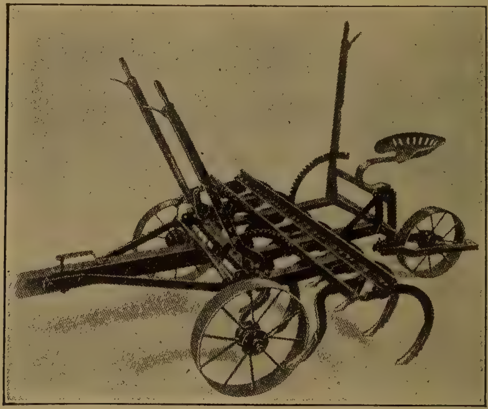


Fig. 189. Petrolithic Heavy Road Cultivator.

Fig. 190. Petrolithic Trailing Road-Asphalt Distributor Spreading Very Light Application on Crushed Stone.

tank wagon, and is not readily detachable. It covers 8 ft. in width. Weight of machine 500 pounds, price $175.

Oil Heater. This machine is mounted on wheels. Weight 10,000 pounds, price $1,200.

All prices f. o. b. Los Angeles, Cal.

TABLE 126 A—COSTS OF PAVING MATERIALS

	Portland Cement per Barrel,			Broken Stone per Cubic Yard,			Sand per Cubic Yard,			Paving Brick per Square Yard,			Asphalt per Ton			Creosoted Wood Block per Square Yd.,			Granite Blk. per Sq. Yd.
	1910	1911.	1912	1910.	1911.	1912.	1910	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1912.
Aberdeen, Wash.		$ 2.40						$ 1 75											
Akron, Ohio	$ 1.35			$ 1.20			$ 0.75			[1]$ 0 72									
Albany, N. Y.	1.70			1.50			1.10			*27.00									
Annapolis, Md		1.50		1.30	[10]$ 1.30			[10].80			[10]$ 1.00								
Ansonia, Conn.	1.52			1.60		[2]$ 1.70	1.25		$ 1.00										
Auburn, Me.				2.20			1.00												
Anderson, Ind.		1.35	$ 1.25		1.00	1.00		.80	.80		.80	$0 .82		$22.00	$20.00				
Albert Lea, Minn.		1.60						.70											
Ames, Ia.		2.00			2.00			1.00									$ 1.33		
Andover, Mass			1.60																
Asbury Park, N. J.			1.20			2.00			1.00			1.23						$ 1.75	$ 2.00
Alpena, Mich.			1.20			1.38			.65										
Ann Arbor, Mich.			1.05			[4].75													
Antigo, Wis.			1.40			1.50			.60										
Atchison, Kan.			1.25			1.05			1.15			63							
Asheville, N. C.			1.90			1.50			.50			24.00±							
Americus, Ga.			1.50			2.35			1.00										
Ashland, Oregon			2.50			2 00			1.40									1.24	
Ashtabula, Ohio			1.30			[4]1.00			.90			.73							[5]1.75
Alton, Ill.			1.00			[13]1.00			[15]1.00			.67							
Albuquerque, N. Mex.			2.20			[4]1.00			.75										
Bath, Me.				3.00			1.00												
Battle Creek, Mich.	1.05	1.09	1.00				65	[24].80		73	.78	.80							
Bay City, Mich.	.90						60			75									
Beaumont, Texas	1.60			1.50			65			1.00			$21.00						
Binghamton, N. Y.	1.20	1.35	1.35	[3]1.00		[4]1.25	1.50	1.00	1 50		[11]20.00								
Bloomington, Ill.	1.25	1.20	1.00	1.30	1.50	1.35	1.10	1.10	1 00	85	.74	.88	30.00	30.00					
Bloomington, Ind.		1.40	1.20		1.00	1.10		1 50	1.65		75	.75							
Buffalo, N. Y.	1.10	1.10	1.10	.90	90	1.15	.90	90	1 50										[5]1.75
Butte, Mont.	2.95	3.10	2.08	[8]1.25	1.80	1.50	.85	1.25	1.00	1 12	1.10	2.60							
Boston, Mass.		1.50			*1.25	35		90	1.35		1.30	1.25		19.00	15.00		2.75	3.00	1.75
Bridgeport, Conn.		1.13	1.45		.90	1.25		1.25	.75		1.37						1.87	1.80	1.64
Bayonne, N. J.		1.15			1.00			.50						30.00					
Burlington, Ia.		1.65	1.32		2.00	2.00		1.25	1 30			.97							
Berkeley, Cal.		2.15			1.25			.50											
Barre, Vt.			1.76			1.26			1 00										1.30
Bristol, Conn.			1.60						1.00										
Benton Harbor, Mich.			1.30			1.20			65			.87							
Bemidji, Minn.			1.50			[4]1 50													
Brookfield, Mo.			1.60			4.10			1.55			.91							
Baltimore, Md.			1.08			1.75			.90			78							1.90
Brunswick, Ga.			85			3.25			1.00			1.50							
Bartlesville, Okla.			1.25			1 50			1.50			70							
Billings, Mont.			2.50			[4]1.60			2 50			1.90						1.80	
Boise, Idaho		3.20	2.70			1.15			1.10			40.00±			25.00				
Boulder, Colo.			2.00			1.25			1.25										
Bellingham, Wash.			2.25			[4]1.25			1.25			1.25							
Cairo, Ill.				1.50			90												
Cambridge, Mass.	1.35	1.25	1.20	1 75	1.50	1 65	1.00	1 00	1.00		28.00±	1.10							1.76
Camden, N. J.	1.25	1.20	1.35	1.35	*1.35	*1.45	.50	50	.70	1.75		16.00±							70.00±
Canton, Ohio						[22].79	1.00		1.25	1.20									
Cedar Rapids, Ia.	1 25			1.35			1.00			.88									
Charleston, S. C.	1.80		[31].31	1.70	*1.68	[36]	.88	1 10	88	1.12	1.27	1.12							
Charlotte, N. C.	1 85			1.25			.75												
Clinton, Ia.	1 60			1 25			.75												
Columbus, Ohio	1.25	1.40	1 25	1 35	85	1.00	1.35	1.30	1.00	75	65	69	24.00		23.00				
Covington, Ky.	1.10			1.15			.90			.70									
Cumberland, Md.	1.25			1 10			.90			*15.85									
Corning, N. Y.		1.30			1.50			1 50			60								
Canton, Ill.								1 40			70								

TABLE 126 A—COSTS OF PAVING MATERIALS (Continued)

	Portland Cement per Barrel, 1910.	1911.	1912.	Broken Stone per Cubic Yard, 1910.	1911.	1912.	Sand per Cubic Yard, 1910.	1911.	1912.	Paving Brick per Square Yard, 1910.	1911.	1912.	Asphalt per Ton, 1910.	1911.	1912.	Creosoted Wood Block per Square Yd., 1910.	1911.	1912.	Granite Blk. per Sq. Yd. 1912.
Chariton, Ia.		1.56			2.00			1.75			75								
Coffeyville, Kan.		1.30	1.00			1 65		1.20	1.60		.65	14.00 ±							
Council Bluffs, Ia.		[22]1.25	97		2.50	2.60		1.25	1.50		1.00	1.00			[22]19.00				
Cortland, N. Y.			1.10			1.00			1.00										
Carbondale, Pa.			1.17			1.23			1.00			•21.00							
Carlisle, Pa.			1 30			1.00			1.40			.78			23.00			1.55	
Chester, Pa			1.40			2.00			1.60			1.10						[14]	1.50
Clearfield, Pa.			1 10			90			.75			70							
Cambridge, Ohio			1.45																
Chillicothe, Ohio			1.30						.60			.67							
Circleville, Ohio			1.10			[4].50			50			62							
Conneaut, Ohio			1.45			[4]1.25			1.25			.64							
Coshocton, Ohio			1.40			[4].75			75						26.00				
Crawfordsville, Ohio			1.25						.60			.70							
Chicago Heights, Ill.			1.00			.95						.85							
Cheboygan, Mich			2.25			•.30			1.00										
Coldwater, Mich.			1.40						[4].50			.82			22.00				
Crookston, Minn.			2.20						1.50										
Charles City, Ia.			1.20			2.60			55										
Creston, Ia.			1.35			2 40			1.35										
Columbia, Mo.			1.15			1 30			1.20			75							
Clarksburg, Va.						2 00			.77										
Columbia, S C.			1 50			2 00			1 00										
Centralia, Wash.			2.50			1 40			1.25										
Davenport, Ia.	1 65	1.15	95	1.25	1.25	1 00	.50	.40	.50	1.00	.94	.93	35.00						
Decatur, Ill.	1.80			1.25			1.00			82									
Denver, Colo.	1.51			1.80			.75												
Detroit, Mich.	.85		.98	.57 ±		1.13	•.50		1.25	85		.85	•24.75		23.00	$1.73		1.82	1.85
Dubuque, Ia.	1.65		1.15	1.00		[15]1.50	1 50		[15]1.50	80		.90							
Dunkirk, N. Y.		1 25			1.50			.75			90								
Danville, Va.		1.70	1.45		2.00	2 00		.85	60		1.08	1.10							1.25
Dayton, Ohio		1.60	1.30			1.50		1 00	1 00			70							
Derby, Conn						1 70			1.00										
Donora, Pa.						1 70			1 70			71							
Du Bois, Pa.			1 10			•1.60			•1 60			64							
Delaware, Ohio			1 50			[16]75			•.90			.85						1.68	
Danville, Ill.			1.10			1.02			1.50			.75							
Dublin, Ga.			1.60			[16]1.70			[16].50										
Dottian, Ala.			1.72						1 00										
Durant, Okla.			[27]2 00			1.70			1.40			1.10			30.00				
East Liverpool, Ohio			1.20						1.00	.48		.47							
Easton, Pa.	1.05			1.02 ±			1.75												
East St. Louis, Ill.	1.10			1 00			78			•65									
Elgin, Ill.	1.25			90			1 10			65									
Elmira, N Y.	1.25		1.40	[7]1.00		[8]1 00	1.00		1.25	1.08		[7].92							
Erie, Pa.	.95		95	[8]1.25		1 50	.85		45	78		70	28.00		26.50				
Evanston, Ill.	1 30			1 25			1 25			85									
Everett, Mass	1.65	1 65	1.57	•.60	1 30	•1 00	1.01	1 27	1 25	1.19	1.16	2.....							1.50
East Orange, N J		1.30			•1 49			1.70											
Elizabeth, N. J		1 15	1.10		1 75	1 50		90	80		1.03	1.20							
Everett, Wash		2.10			[24]1.50			1.50			1.59								
Evansville, Ind		1 30	1.15		1 25	[4]1.00		1 00	1 00		20.00 ±			19.00			1.35		
Easthampton, Mass.			1 45			1.25			.50										
Edwardsville, Ill.			1.20			1.10			.90			72							
Escanaba, Mich			1.30			.90			.50						19.00				
Emporia, Kan						1.54			1.25										
Findlay, Ohio				60			1.00												
Fitchburg, Mass.	1 60	1 90		62 ±	[1]1.00		65	60											
Fort Dodge, Ia.	1 30		1 60	1 60		1 90	1.25		1.10										
Fort Smith, Ark.	1 60			1 25			60												

TABLE 126 A—COSTS OF PAVING MATERIALS (Continued)

	Portland Cement per Barrel,			Broken Stone per Cubic Yard,			Sand per Cubic Yard,			Paving Brick per Square Yard,			Asphalt per Ton			Creosoted Wood Block per Square Yd.,			Granite Blk. per Sq. Yd.,
	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.	1912.
Fort Wayne, Ind.	1.40	.....	1.05	1.05	.....	.98	.90	.....	1.10	.88	.....	.87	.....	.....	27.00	.....	.....	1.60	2.50
Freeport, Ill.	1.40	1.35	1.40	[10].50	.50	.85	1.00	[20]1.00	1.10	.75±	.88	.85	.....	.....	.....	.....	.....	1.35	.....
Fresno, Cal.	2.25	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	.....	.....	.....	12.50	15.00	15.00	.....	.....	.....	.....
Fulton, N. Y.	....	.....	.....	.....	[11]1.25	.....	.....	.85	.....	.....	24.50±	.....	.....	.....	.....	.....	.....	.....	.....
Flint, Mich.	....	1.40	1.60	.....	.....	.....	.....	1.00	1.60	.....	.70	.80	.....	.....	.....	.....	.....	.....	.....
Franklin, Pa.	....	.....	1.15	.....	.....	.....	.....	.....	1.25	.....	.....	18.00±	.....	.....	21.00	.....	.....	.....	.....
Fostoria, Ohio	....	.....	1.10	.....	.....	.60	.....	.....	.90	.....	.....	.70	.....	.....	.....	.....	.....	.....	.....
Fremont, Ohio	....	.....	1.30	.....	.....	1.00	.....	.....	1.00	.....	.....	.72	.....	.....	.....	.....	.....	.....	.....
Frankfort, Ind.	....	.....	1.00	.....	.....	1.25	.....	.....	.90	.....	.....	.66	.....	.....	.....	.....	.....	.....	.....
Fond du Lac, Wis.	....	.....	1.25	.....	.....	.95	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Falton, Mo.	....	.....	1.40	.....	.....	1.75	.....	.....	2.00	.....	.....	.70	.....	.....	18.00	.....	.....	.....	.....
Fremont, Neb.	....	.....	1.60	.....	.....	.90	.....	.....	.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Scott, Kan.	....	.....	.90	.....	.....	1.25	.....	.....	1.80	.....	.....	.72	.....	.....	.....	.....	.....	.....	.....
Frederick, Md.	....	.....	1.30	.....	.....	.75	.....	.....	1.50	.....	.....	1.05	.....	.....	.....	.....	.....	.....	.....
Grand Rapids, Mich.	1.10	1.50	1.10	[11]1.60	1.50	[4].85	.60	1.00	.65	.86	1.20	.84	.....	.....	23.00	1.60	.....	.....	.....
Gary, Ind.	....	1.10	1.20	.....	.85	1.20	.....	1.15	[3]1.25	.....	.88	.90	.....	.....	.....	.....	.....	.....	.....
Greenville, Pa.	....	.....	1.10	.....	.....	1.00	.....	.....	.90	.....	.....	.62	.....	.....	.....	.....	.....	.....	.....
Galion, Ohio	....	.....	.....	.....	.....	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Granite City, Ill.	....	.....	1.10	.....	.....	[15]1.35	.....	.....	[15].95	.....	.....	.72	.....	.....	.....	.....	.....	1.50	.....
Grand Forks, N. D.	....	.....	1.65	.....	.....	3.75	.....	.....	[4]1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Greensboro, N. C.	....	.....	2.00	.....	.....	1.85	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Greensboro, S. C.	....	.....	2.00	.....	.....	2.25	.....	.....	.75	.....	.....	32.00±	.....	.....	.....	.....	.....	.....	.....
Gainesville, Fla.	....	.....	1.85	.....	.....	3.00	.....	.....	.50	.....	.....	1.40	.....	.....	.....	.....	.....	.....	.....
Gadsden, Ala.	....	.....	1.20	.....	.....	1.00	.....	.....	1.65	.....	.....	21.00±	.....	.....	.....	.....	.....	.....	.....
Greenville, Texas	....	.....	1.70	.....	.....	.....	.....	.....	2.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Great Falls, Mont.	....	.....	2.52	.....	.....	[4]1.40	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	1.66	.....
Grand Junction, Colo.	....	.....	2.60	.....	.....	.90	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hamilton, Ohio	....	1.25	1.05	1.25	1.25	1.25	.90	1.00	1.00	.....	.90	.....	.....	.....	.....	.....	.....	.....	.....
Harrisburg, Pa.	....	.....	.....	1.00	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hartford, Conn.	[12]1.55	1.40	1.55	1.75	*1.35	[8]1.25	1.25	.77	.75	.....	.....	.....	30.00	27.00	30.00	.....	.....	.....	.....
Haverhill, Mass.	[13]1.64	1.55	.....	1.10	*1.10	.....	[14].25	.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Helena, Mont.	2.50	2.45	2.40	1.50	1.25	1.40	1.00	1.00	1.25	*22.00	.58	1.30	.....	.....	.....	.....	.....	.....	.....
Holyoke, Mass.	1.32	.....	1.25	[15]1.30	.....	1.20	[16].10	.....	.10	.....	.....	1.22	.....	.....	.....	1.63	.....	.....	1.48
Hornell, N. Y.	....	1.25	1.17	.....	1.15	1.15	.....	1.00	1.00	.....	.76	.....	.....	.....	.....	.....	.....	.....	.....
Hudson, N. Y.	....	.....	1.30	.....	.75	.78	.....	.....	1.25	.....	.....	1.10	.....	.....	.....	.....	.....	.....	.....
Hoquiam, Wash.	....	2.80	2.75	.....	1.00	1.50	.....	1.00	.75	.....	1.50	3.00	.....	.....	.....	.....	.....	.....	.....
Hyde Park, Mass.	....	.....	.....	.....	.....	1.35	.....	.....	1.65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hazleton, Pa.	....	.....	1.50	.....	.....	.75	.....	.....	2.00	.....	.....	.84	.....	.....	.....	.....	.....	.....	.....
Harrisburg, Ill.	....	.....	1.40	.....	.....	2.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hillsdale, Mich.	....	.....	.95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Holland, Mich.	....	.....	1.30	.....	.....	1.20	.....	.....	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hutchinson, Kan.	....	.....	1.30	.....	.....	2.00	.....	.....	.60	.....	.....	.90	.....	.....	25.00	.....	.....	1.50	.....
Hagerstown, Md.	....	.....	1.25	.....	.....	1.12	.....	.....	1.50	.....	.....	1.00	.....	.....	.....	.....	.....	.....	.....
Indianapolis, Ind.	1.75	.....	1.30	1.50	.....	.....	1.50	.....	[24]1.07	1.00	.....	2.00	23.80	.....	24.00	1.65	.....	2.90	.....
Independence, Kan.	....	1.30	1.00	.....	1.25	1.20	.....	1.65	1.80	.....	.60	.65	.....	22.50	22.00	.....	.....	.....	.....
Jamestown, N. Y.	....	1.23	1.25	.....	1.50	1.50	.....	1.75	1.75	1.75	[14].78	.78	.....	13.50	[8]13.50	.....	.....	.....	.....
Jersey City, N. J.	....	1.50	.....	.....	1.50	2.50	.....	1.25	1.40	.....	2.50	1.40	.....	.....	.....	.....	3.15	.....	.....
Johnstown, N. Y.	....	.....	1.22	.....	.....	2.08	.....	.....	.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Jacksonville, Ill.	....	.....	1.20	.....	.....	*.85	.....	.....	*.60	.....	.....	1.00	.....	.....	.....	.....	.....	.....	.....
Joliet, Ill.	....	.....	1.10	.....	.....	1.10	.....	.....	1.00	.....	.....	.45	.....	.....	.....	.....	.....	.....	.....
Jefferson City, Mo.	....	.....	1.60	.....	.....	1.25	.....	.....	1.25	.....	.....	.75	.....	.....	[25]18.00	.....	.....	.....	.....
Jonesboro, Ark.	....	.....	1.87	.....	.....	1.60	.....	.....	1.65	.....	.....	1.12	.....	.....	.....	.....	.....	.....	.....
Kansas City, Mo.	[17]1.00	.....	1.00	[18]1.25	.....	1.45	1.25	.....	.90	.64	.....	.....	28.00	.....	.....	2.10	.....	.....	.....
Keokuk, Ia.	....	1.40	1.40	[19]1.25	1.25	1.25	[20]1.10	1.50	1.40	.....	1.75	1.70	.....	.....	25.00	.....	.....	.....	.....
Kingston, N. Y.	[21].85	1.20	*1.40	1.00	1.33	1.00	.50	.50	.60	.....	.90	1.15	.....	.....	[10].....	.....	.....	.....	.....
Knoxville, Tenn.	[22]1.50	.....	1.50	[23]1.25	.....	1.35	[24].80	.....	1.00	[25]*19.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kalamazoo, Mich.	....	1.14	1.14	.....	.....	.....	.....	.60	.75	.....	.....	.86	.....	.....	.....	.....	.....	.....	.....
Kokomo, Ind.	....	.....	1.15	.....	.....	1.00	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kirksville, Mo.	....	.....	1.12	.....	.....	2.00	.....	.....	1.35	.....	.....	.92	.....	.....	.....	.....	.....	.....	.....
Kansas City, Kan.	....	.....	1.00	.....	.....	1.50	.....	.....	1.00	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....

TABLE 126 A—COSTS OF PAVING MATERIALS (Continued)

	Portland Cement per Barrel, 1910.	1911.	1912.	Broken Stone per Cubic Yard, 1910.	1911.	1912.	Sand per Cubic Yard, 1910.	1911.	1912.	Paving Brick per Square Yard, 1910.	1911.	1912.	Asphalt per Ton, 1910.	1911.	1912.	Creosoted Wood Block per Square Yd., 1910.	1911.	1912.	Granite Blk. per Sq. Yd. 1912.
La Crosse, Wis.	1.10			1.15			.50			70									
Lawrence, Kan.	1.40	1.80		1.65	1.50		.60	.75		.63	10.00±								
Leavenworth, Kan.	1.18	[32]1.60		2.00	[32]1.75		.50	[32].90		.60	[32].66								
Lewiston, Me.				2.20			1.00												
Lincoln, Neb.	1.20	1.60	1.25	1.50	1.75	1.75	.75	70	.75	[26].95	.95	.90							
Little Rock, Ark.	1.70			1.75			.80			1.00			30.00						
Lowell, Mass.	1.33	[4]1.30	1.24	2.40	2.00			1.20	.15	[27]1.24									1.15
Lynn, Mass.	.85		1.65	.85±		.80	.95±		.90										1.49
Lawrence, Mass.		2.00	2.00		*[3]1.10	*1.10		.75	.50								2.60		1.18
Little Falls, N. Y.		1.22	1.32		[15]1.50	1.50		[15]1.00	1.00										[11]1.45
Lansing, Mich.		1.50			[24]1.00			1.00			.80								
Lima, Ohio		1.30	1.25		1.00	1.10		1.20	1.10		.70	.75			28.00				
Logansport, Ind.		1.50	1.25		1.00	1.00		.80	1.00			.80							
Lorain, Ohio			1.30		1.20	1.20		1.20	1.25										
Laconia, N. H.						*1.19			1.00										
Lancaster, Ohio									.50			.75							
Laporte, Ind.			.95			1.50			1.10			21.00±			[25]20.00				
La Grange, Ill.			[15]1.10			[15]1.20			[15]1.50										
La Salle, Ill.			1.10			1.35			1.25			.85							
Lexington, Mo.			[31]1.40			1.50													
Lexington, Ky.			1.40			*.90			1.60			.70			22.00				
Louisville, Ky.			1.10			1.00			1.00			16.00±						2.89	3.00
Longview, Texas			1.65			2.20			2.20									2.45	
Madison, Wis.	1.35			[28]1.13			[29].90						25.00			1.80			
Manistee, Mich.	1.40			1.20			.60												
Mankato, Minn.		.65	1,20	.80	1.25	1.00	.50	.30	.70									1.55	
Marion, Ind.	1.20			1.25			.60			.74			28.70						
Meridian, Miss.	[30]1.22		1.35	[31]1.50		1.40	1.00		1.00	*20.00						[32]1.30			
Minneapolis, Minn.	1.15	1.25	1.25	1.80	1.75	[15]2.40	.80	.75	[15].70	.97	[6].98	1.00				1.58	1.33	[28]	[29]1.49
Muskegon, Mich.	1.15			[33]1.20	1.25		[34]1.00												
Malden, Mass.		1.70			1.75			1.00											
Meriden, Conn.		2.20			* .55			1.20											
Middletown, Conn.					1.05														
Middletown, N. Y.		1.50			1.00			.70			.94								
Macon, Ga.		1.60			1.25			.70			1.00								
Marion, Ill.		1.35			1.35			1.00			.75			22.00					
Mattoon, Ill.		1.10	1.10		1.35	1.30		1.00	1.00		.70	.68		19.00	19.00				
Milwaukee, Wis.		1.30			1.30			.95			.90			25.00			1.40		
McAlester, Okla.		1.72									2.00								
Muskogee, Okla.		[33]1.70	1.30		[33]1.35	1.50		[30]80	.90			.80		[33]27.00	28.00				
Mt. Vernon, N. Y.			1.20			1.10			.50			1.10							
Meadville, Pa.			1.25						.50			.70							
Monongahela, Pa.			1.20									.70							
Massillon, Ohio			1.00						1.00			.60							
Mt. Vernon, N. Y.			1.32						1.30			.70							
Mishawaka, Ind.			1.25			[30]1.50			.80			.85			25.00				
Muncie, Ind.			1.20			1.13			1.00			.72							
Macomb, Ill.			1.30			1.50			1.00										
Mt. Carmel, Ill.						1.16			.40			1.00							
Menasha, Wis.			1.25			1.25			1.10										
Merrill, Wis.						.65													
Marinette, Wis.			1.55			1.15			[15].75										
Marshalltown, Ia.			1.05			[4]1.00			1.00										
Mason City, Ia.			1.25			1.35			.70										
Moberly, Mo.			1.20			3.25			1.40			15.00±							
Manhattan, Kan.			1.65			1.65			.50			.70			30.00				
Missoula, Mont.			2.40			1.90			2.00										
Medford, Oregon			3.00			1.25													
New Albany, Ind.	1.16	1.15		.90	[31]1.00		.80	.80		.70	.74								
New Bedford, Mass.	1.22	1.27	1.20	1.52	1.56	1.40	1.07	1.10	1.19										1.65

TABLE 126 A—COSTS OF PAVING MATERIALS (Continued)

	Portland Cement per Barrel, 1910.	1911.	1912.	Broken Stone per Cubic Yard, 1910.	1911.	1912.	Sand per Cubic Yard, 1910.	1911.	1912.	Paving Brick per Square Yard, 1910.	1911.	1912.	Asphalt per Ton, 1910.	1911.	1912.	Creosoted Wood Block per Square Yd., 1910.	1911.	1912.	Granite Blk. per Sq. Yd. 1912.
New Castle, Pa.	1.15	1.15	1.00	1.30		.65	1.50	[17].75	.75	.70	15.25±	.60							
Newport, R. I.	1.55																		
Newton, Mass.	1.60	1.70		1.35	1.20		.50	.40											
Norristown, Pa.	1.35			[38]1.55			[38]1.01			[37].99									
New Brunswick, N. J.		1.20	1.15		1.50	1.60		1.00	1.10		[16]24.00±	1.20							
Niagara Falls, N. Y.		1.35	1.20		1.40	1.00		1.25	1.00			.95							
N. Tonawanda, N. Y.		1.40	1.15		1.25	1.25		1.00	1.00		.80	2.50							
Norfolk, Va.					1.60			1.00									2.00		
Newark, Ohio		1.20			[39]1.00			.75			.60								
North Yakima, Wash.		2.70			1.50			1.50			2.90								
Newburyport, Mass.			1.32			1.60			.65										
New London, Conn.						•1.20			1.25										
Norwalk, Conn.			1.36			1.10			.90			2.55							
Norwich, Conn.			1.36			1.10			1.00			1.00							
Niles, Ohio						•.80			•.80			16.50±							
Norwood, Ohio			1.25			2.00			1.50										
Newcastle, Ind.			1.00			[4].75			•.75			.80							
Newton, Kan.			.95			1.35			.95			17.00±							
New Bern, N. C.			1.70			1.90			1.25			.90							
New Orleans, La.			1.65			[4]1.90			1.50			1.40			22.75			1.75	54.00±
Napa, Cal.			2.40			1.12			.75										
Ottawa, Ill.	1.35	1.20	1.21	1.25	1.35	[4]1.00	.75	.75	.78	.76	.78			19.00					
Ogdensburg, N. Y.		[18]1.60			1.07			1.07											
Olean, N. Y.		1.25			1.50			1.40			1.45								
Oneida, N. Y.		1.40	1.20		1.40	1.26		.80	1.00		.96	1.00							
Oneonta, N. Y.		1.30			1.50	1.60		1.50	1.00		1.02								
Ottumwa, Ia.		1.70	1.30		1.75	1.75		1.00	1.00		.80	.75					1.50	[30]1.65	
Oklahoma City, Okla.		1.60	1.50		2.00	2.00		1.00	1.25		1.00	.95		35.00	40.00				
Ogden, Utah		2.10			[31]1.25			1.25						22.00					
Oil City, Pa.			[15]1.10			[17].80			[18].80										
Olney, Ill.			1.10			[4]1.30			1.30			.70							
Ottawa, Kan.			1.10			1.50			.90			.63			17.00				
Owensboro, Ky.			1.60			.90			1.25										
Passaic, N. J.				2.10			.50												
Pawtucket, R. I.	1.55						[39].10												
Pensacola, Fla.	1.75	1.35			1.90	[34]	1.10	1.10											
Peoria, Ill.	1.20	1.28	1.10	1.27	[34]1.25	1.30	1.00	1.00	1.00	.73		.70		33.00			1.87	1.50	
Pine Bluff, Ark.	1.64			2.00			1.00												
Port Huron, Mich.	.93	1.10	.95		1.40	[4].64		.90	.50		.85	.85							
Portland, Me.	1.69	1.75	1.30	•1.20±	1.50	1.50		1.10	1.00	1.09		1.05	[39]3.83						1.25
Portland, Ore.	2.30		2.00	2.00		1.00	1.40		.75			1.45			14.00			[40]42.00±	[41]2.15
Providence, R. I.	1.56	1.33	[1]1.51	1.50	1.69	1.70	[41].15	[4].64		1.00	1.25								1.65
Provo, Utah	2.00			[40].75			.75												
Pasadena, Cal.		2.40			1.60			.50						22.00					
Pittsfield, Mass.			1.50																
Plattsburgh, N. Y.			2.00			1.25			.50										
Plainfield, N. J.			1.50			1.90			1.00										
Pittsburg, Pa.			1.80			3.00			1.25			.70			30.00			2.20	[31]1.20
Pekin, Ill.			1.60			1.65			1.25			.95			[37]23.00				
Pontiac, Mich.			1.25			[4].85			.80			.80							
Pittsburg, Kan.			1.35			[30]1.75			1.50			.64							
Portsmouth, Va.			1.50			1.65			.75										
Paris, Ky.			1.75			1.00			.12										
Port Arthur, Texas			1.50			[38]			[15]1.25									1.45	
Pomona, Calif.			2.50			1.75			.90										
Racine, Wis.	1.70			1.30			1.00			.85									
Reading, Pa.	[43]1.01	1.20		[43]1.20	•1.20		•1.00	•1.20		1.50	.94			25.00					
Richmond, Md.	1.50			.87			1.00												
Rochester, N. Y.	1.25	1.60	1.50	1.50	1.50	1.50	1.25	1.25	1.25	.90	.85	.85							
Rockford, Ill.	1.30	2.00	1.10	.50	.75	.75	1.00	1.00	1.00		1.85								

TABLE 126 A.—COSTS OF PAVING MATERIALS (Continued)

	Portland Cement per Barrel, 1910.	1911.	1912.	Broken Stone per Cubic Yard, 1910.	1911.	1912.	Sand per Cubic Yard, 1910.	1911.	1912.	Paving Brick per Square Yard, 1910.	1911.	1912.	Asphalt per Ton, 1910.	1911.	1912.	Creosoted Wood Block per Square Yd., 1910.	1911.	1912.	Granite Blk. per Sq. Yd. 1912.
Rock Island, Ill.	1.20			1.00			.90			•15.00									
Richmond, Ind.		1.35	1.25		.90	1.00		1.00	1.00		.78	19.00							
Ravenna, Ohio			1.25						1.00			.87							
Rome, Ga.			1.10			.90			1.25										
Richmond, Calif.			2.00			1.25			1.00						12.00				
Saginaw, Mich.	1.00	1.20	1.32	1.45	1.45	1.45	.90	1.00	1.00	.75	.76	.78	28.00						
Salt Lake City, Utah	2.00	2.25	2.25	1.25	1.00	1.25	1.25	1.00	1.00				27.00	36.00	30.00				
San Jose, Calif.	2.20	2.60	2.40	1.60	1.60	1.75	1.00	1.50	1.50				15.00	16.00	16.00				
Scranton, Pa.	1.40	1.40	1.20	1.50	1.25	1.50	1.25	1.25	1.25	1.00	24.00±	.90	26.00	26.00	26.00				
Seattle, Wash.	2.20	[35]2.10	2.00	[41].90	[33]1.50	2.00	[15].90	[35].90	.90	1.20	[35]20.00±	1.20	[46]20.00	[36]18.00	15.00	[47]1.30		1.15	2.05
Selma, Ala.	[46]1.75						.40			.80			25.00						
Sheboygan, Wis.			1.35	1.25		1.25	.75		1.00	1.05		1.05							
Sioux City, Ia.	1.30	1.60	1.12	2.10	2.00	2.00	1.15	1.15	1.05	[49]16.00	.65					1.30			
Somerville, Mass.	[30]1.15			[31]1.05															
South Bend, Ind.	1.20			1.25			.90												
Spokane, Wash.	2.75	2.80	2.30	1.25	1.50	1.50	1.10	1.25	1.25	•28.00	1.35	1.80	26.00	25.00	21.00			1.90	3.00
Springfield, Ill.	.98		1.15	1.20		[13]1.50	.75		.90	.65		.60	22.00		25.00				
Springfield, Mass.	1.44	1.56	1.43	.85±	[46].85	1.05	1.00	1.00	1.25							2.10	[6]2.10	2.10	
Springfield, Mo.	[52]1.35			[33]1.00			1.50			.90			34.00						
S. Omaha, Neb.	1.00	2.28	1.00	1.62	2.20	2.25	.60	2.20	1.25	•23.00	1.02	1.02		22.00					
St. Louis, Mo.	1.35	1.65	1.00	1.15	1.20	1.20	1.15	1.35	1.00	.80	.80	.83		25.00	22.00	1.50	1.50	1.55	1.50
Streator, Ill.	1.25	2.00	1.40	1.10	1.25	1.45	1.00	1.00	1.00	.71	.80	.78							
Superior, Wis.	1.25		1.65	1.70		1.25	.75		.75	1.00		1.02			28.00	1.40		1.40	
Syracuse, N. Y.	1.30	[30]1.35	1.35	[54]1.25	[21]1.35	1.25	[53]1.00	[33]1.00	1.00			1.00							[12]1.50
Stamford, Conn.		1.21			1.00			1.75			1.26								
Schenectady, N. Y.		1.25			1.70			1.25											
Springfield, O.		1.30	1.30		1.00	1.25		1.00	1.25		.72	.72		28.00	28.50				
San Antonio, Tex.		2.68	[36].57		•1.15	1.50		•1.00	1.50					24.00	20.00				
Shawnee, Okla.		1.60			1.65			1.00			.65			28.00					
San Diego, Cal.		2.00	2.00		2.25	2.00		1.25	1.00					20.00					
San Francisco, Cal.		2.55			1.00			1.73						14.70					
Southbridge, Mass.			1.60						1.75										
Summit, N. J.									2.50										
Sayre, Pa.			1.10			1.25			1.25			22.50±			21.00				
S. Bethlehem, Pa.			1.10			1.50			1.50										
Seymour, Ind.			1.30						.75										
St. Joseph, Mich.			1.05			1.60			.40			.88							
St. Charles, Mo.			.96			1.75			1.15										
Sedalia, Mo.			1.40			•1.25			1.40			.80							
Salina, Kan.			1.50			1.75			2.25			1.00							
Staunton, Va.			1.20			1.25			1.50										
Suffolk, Va.			1.20			1.65			1.10			1.00							
Spartanburg, S. C.			1.75			1.30			.50						25.00				
Salem, Oregon			2.35			1.75			1.75										
San Bernardino, Cal.			2.60			1.25			.75										
Santa Cruz, Cal.						1.25			.75										
St. Albans, Vt.						1.00			1.35										
Tacoma, Wash.	2.60	2.25		1.50	3.25		1.50	1.50		1.20	1.40								
Terre Haute, Ind.	1.30			[56].85					.85	.75		.85							
Topeka, Kan.	1.40	1.35	1.20	1.80	1.85	1.80	1.00	.80	.75	.84	12.00±	.80			25.00				
Toledo, Ohio				[57]1.05			[58].60			•18.00			28.00						
Trenton, N. J.	1.50		1.34	2.10		1.60	1.33		.90	.95		1.10							
Troy, N. Y.	1.80	1.60		1.50	1.50		1.10	1.25											
Torrington, Conn.			1.45			1.00			.50										
Temple, Texas			2.25			•1.20			1.50			.65							
Tulsa, Okla.			1.45			1.35			.90			12.00±			28.00				
Twin Falls, Idaho			2.73			2.00			[121]1.65										
Utica, N. Y.	[59]1.25	1.50	1.20	1.25	1.60		1.00	1.00											
Valparaiso, Ind.				1.15			.60			.85									
Vicksburg, Miss.	1.80	1.80	1.80	[60]1.75	[35]1.60	•1.00	1.65	1.50	.90			2.075			20.00			2.55	

TABLE 126 A—COSTS OF PAVING MATERIALS (Concluded)

	Portland Cement per Barrel, 1910.	1911.	1912.	Broken Stone per Cubic Yard, 1910.	1911.	1912.	Sand per Cubic Yard, 1910.	1911.	1912.	Paving Brick per Square Yard, 1910.	1911.	1912.	Asphalt per Ton, 1910.	1911.	1912.	Creosoted Wood Block per Square Yd., 1910.	1911.	1912.	Granite Blk. per Sq. Yd., 1912.
Vancouver, Wash.	....	2.60	2.30	.....	1.25	1.60	.....	1.00	1.50	.....	.....	.....	.....	19.00	.....	.....	.....	.....	.....
Washington, D. C.	1.32	.99	1.00	[61]1.50	1.50	[36]1.50	.55	.39	.40	.95	.96	.88	.....	.....	.....	.....	.....	.....	.....
Watertown, N. Y.	1.40	1.35	1.35	1.00	1.25	1.45	1.00	1.00	1.00	1.08	1.12	1.10	.....	.....	.....	.....	1.60	.....	.....
Wheeling, W. Va.	....	.....	.....	.....	.....	.....	1.30	.....	.....	.65	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wilkesbarre, Pa.	1.40	1.35	1.30	.90	1.50	1.25	1.35	1.25	1.00	.....	1.00	1.08	.....	.....	.....	.....	.....	.....	.....
Worcester, Mass.	1.34	[7]1.32	1.86	1.65	*[8]1.10	1.25	1.25	1.25	1.25	1.15	.....	.....	.....	.....	.....	2.25	.....	.....	1.55
Williamsport, Pa.	....	1.50	.....	.....	1.20	.....	.....	75	.....	.....	18.00±	.....	.....	.....	.....	.....	.....	.....	.....
Waukegan, Ill.	....	1.50	1.30	.....	1.40	1.35	.....	1.25	1.00	.....	.90	.88	.....	20.00	17.00	.....	.....	.....	.....
Waterloo, Ia.	....	1.40	1.25	.....	1.50	1.50	.....	1.00	1.00	.....	1.00	.....	.....	30.00	.....	.....	.....	.....	.....
Wichita, Kan.	....	1.50	1.22	.....	1.30	1.15	.....	.10	1.00	.....	.90	.75	.....	.....	.....	.....	1.50	1.90	.....
Waco, Texas	....	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Walla Walla, Wash.	....	3.19	2.60	.....	.....	1.75	.....	.....	1.60	.....	.....	.....	.....	.....	21.00	.....	.....	.....	.....
Westfield, Mass.	....	.....	1.65	.....	.....	.60	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Waterbury, Conn.	....	.....	1.65	.....	.....	1.10	.....	.....	1.50	.....	.....	32.00±	.....	.....	.....	.....	.....	.....	.....
Willimantic, Conn.	....	.....	1.35	.....	.....	1.60	.....	.....	1.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.14
Watervliet, N. Y.	....	.....	1.40	.....	.....	1.50	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
White Plains, N. Y.	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.25	.....	.....	.....	.....	.....	.....	.....
Westfield, N. J.	....	.....	1.25	.....	.....	1.90	.....	.....	1.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
West New York, N. J.	....	.....	1.35	.....	.....	1.50	.....	.....	1.50	.....	.....	1.20	.....	.....	.....	.....	.....	.....	.....
West Orange, N. J.	....	.....	.....	.....	.....	1.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Warren, Pa.	....	.....	1.10	.....	.....	1.00	.....	.....	1.00	.....	.....	.78	.....	.....	12.00	.....	.....	.....	.....
Washington, Pa.	....	.....	1.15	.....	.....	1.50	.....	.....	1.05	.....	.....	.50	.....	.....	.....	.....	.....	.....	.....
Wilkinsburg, Pa.	....	.....	1.00	.....	.....	2.25	.....	.....	.....	.....	.....	1.37	.....	.....	.....	.....	.....	.....	[illegible]2.25
Wooster, Ohio	....	.....	1.30	.....	.....	1.10	.....	.....	.80	.....	.....	.375	.....	.....	.....	.....	.....	.....	.....
Washington, Ind.	....	.....	1.00	.....	.....	1.10	.....	.....	.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Waukesha, Wis.	....	.....	1.40	.....	.....	1.35	.....	.....	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wausau, Wis.	....	.....	1.75	.....	.....	1.20	.....	.....	.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winona, Minn.	....	.....	.....	.....	.....	1.25	.....	.....	.75	.....	.....	.97	.....	.....	.....	.....	.....	.....	.....
Webb City, Mo.	....	.....	1.10	.....	.....	[32].60	.....	.....	2.00	.....	.....	.85	.....	.....	27.50	.....	.....	.....	.....
Wellington, Kan.	....	.....	[34].30	.....	.....	2.00	.....	.....	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Weatherford, Texas	....	.....	2.20	.....	.....	[4].50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
York, Pa.	....	.....	1.20	.....	.....	1.00	.....	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Zanesville, Ohio	1.50	.....	1.30	[63]1.00	.....	1.10	1.00	.....	.80	.60	.....	.375	.....	.....	.....	.....	.....	.....	.....

1910: * Per M. ± Per ton. 1—72c to 84c, depending on length of haul. 2—Screened gravel. 3—Broken slag. 4—50c to 61c. 5—$24.75 and $26.80. 6—65c to 70c. 7—Gravel. 8—Washed gravel delivered. 9—60c to 70c. 10—Furnished by city. 11—Gravel at 85c per cu. yd. 12—$1.25 net. 13—Delivered. 14—Delivered in cars in freight yard. 15—F. o. b. Holyoke. 16—At bank. 17—$1 to $1.20. 18—$1.25 to $1.50. 19—On car. 20—On job. 21—In bags, 7½c allowed on each bag returned. 22—Net. 23—$1.25 to $1.35. 24—80c to $1.00. 25—$19 to $25. 26—95c to $1.10. 27—Block granite. 28—$1.13 to $1.60. 29—90c to $1.25. 30—For large contract. 31—Gravel. 32—20 lb. treatment. 33—Loaded on wagon at dock. 34—On car. 35—Limestone $1.55, trap $1.89. 36—Delivered. 37—Blocks. 38—In bank. 39—Per bbl. 40—Gravel. 41—In bank. 42—With bags at 7½c returned. 43—Trap. 44—Gravel at bunkers. 45—At bunkers. 46—Asphaltic cement. 47—For 4-in. blocks at dock. 48—Portland, $1.75, natural $1.00. 49—Blocks, $20 per M., brick $16 per M. 50—$1.15 to $1.30. 51—Per ton on cars. 52—$1.35 to $1.50. 53—$1 to $1.15. 54—$1.25 to $1.50. 55—$1 to $1.15. 56—Bank gravel. 57—F. o. b. cars. 58—On dock. 59—$1.25 to $1.50. 60—Gravel. 61—Plus haul. 62—Gravel.

1911: * Per ton. ± Per M. 1—At crusher. 2—On cars at Haverhill. 3—F. o. b. cars. 4—On street. 5—85c to $1.20. 6—F. o. b. Springfield. 7—In paper, $1.32; in cloth, $1.62. 8—$1.10 to $1.50. 9—$1.50 for 4½-in block. 10—F. o. b. Annapolis. 11—18c to 20c, f. o. b. city. 12—Trap blocks. 13—Gravel. 14—78c to 90c. 15—Delivered. ±16—$24 to $32. 17—Bank sand and gravel. 18—Car load lots $1.40. 19—Stone block. 20—$1.35 to $1.65. 21—$1.35 to $1.50. 22—$1 to $1.25. 23—Sandstone blocks. 24—Gravel. 25—Gravel on job. 26—On job. 27—Seconds. 28—Imported; local sand 25c; delivered 80c 29—Creek gravel used for paving work cost 5c per cu. yd. plus cost of hauling. 30—Delivered. 31—$1.25 to $2.00. 32—Delivered on street. 33—F. o. b. 34—Per M. for basalt blocks. 35—At yards or bunkers. 36—Sandstone blocks.

1912: * Per ton. ± Per M. 1—$1.33 net. 2—Delivered. 3—$1.25 to $1.45. 4—Gravel. 5—Medina. 6—Gravel (pebbles). 7—Corning re-pressed blocks. 8—Pitch. 9—Rosendale $0.68. 10—Asphalt binder, per gal. $0.08. 11—F. o. b. quarry. 12—Sandstone block. 13—Gravel per ton. 14—3-in. at $2.74; 3½-in. at $2.94; 4-in. at $3.64. 15—Delivered on the work. 17—Gravel, $0.80 to $1.00. 18—$0.80 to $1.00. 19—$1.50 for class "A." 20—Ligonier. 21—Broken slag. 22—Gravel at bank. 23—Torpedo. 24—Coarse sand, $0.95. 25—Asphalt filler. 26—Gravel, $0.80. 27—Sarco. 28—4-in. at $1.59; 3½-in. at $1.40. 29—Sandstone block $1.55. 30—For 3¼-in. 31—By carload. 32—Crushed stone for concrete consists of mine tailings and were had for hauling, which averaged $0.35. 33—Joplin chats at $0.80. 34—Per 100 lbs. 35—Trap rock. 36—2-in. at $1.60; 1¼-in. at $1.73; ¾-in. at $1.79; screenings at $1.32. 37—From $1.25 to $2.00. 38—1½-in. $2.60; 2½-in. $2.30. 39—Per 95-lb. bag; bag to be returned. 40—Avenarine carbolmeum wood block. 41—Basalt block.

PHOTOGRAPHY

No construction work, however small, should be carried on without the assistance of the camera. For motion study it is indispensable, and, as an adjunct to the keeping of records, nearly so. Photographs of construction work have saved many dollars to the contractor in employees' damage suits, and to the owner or contractor in other legal cases.

On unimportant work, pictures less than 4x5 inches are sufficiently large for all purposes, as small pictures can be enlarged to 8x10 inches or more, if necessary. After much experimenting in this line, the author uses an Eastman folding pocket kodak No. 3, which holds a 6 or 12-exposure film roll, and takes a picture 3¼x4¼ inches. This type of camera is convenient as it occupies very little space when folded. The picture is large enough to show fair sized groups and details.

On important work large pictures should be taken not less often than once each month, and more frequently if the work is of sufficient size and progress to warrant the expense. For this purpose the Empire State plate camera, taking a picture 8x10 inches, is recommended. For general use a No. 5 Goerz Dagor F: 6.8 or U. S. 2.9 lens is very good. When this lens is wide open it covers a 7x9 inch plate; when open at F:16 or U. S.:16 it covers an 8x10 inch plate, and at F:32 or U. S.:64 it covers a 12x16. For a wide angle lens the No. 2, listed to cover a 5x7, has a greater speed and better definition than a regular wide angle lens. While this lens is listed to cover a smaller plate than 8x10 it is actually large enough. This lens is convertible; the full combination—equivalent focus 10¾ inches—may be used for general work and the back combination—equivalent focus 21 inches—for objects at a distance.

For glossy prints, to show extreme detail, use glossy Velox; for general results, but extreme detail, velvet Velox. In order to secure compactness use the ready made developer. The "Tabloid" brand is very handy. Always keep a 10 per cent solution of bromide of potash at hand to slow down the developer. A room 4 ft. x 6 ft. is all that is necessary for developing pictures. If there is a window, cover it with a piece of red glass and 2 sheets of yellow P. O. paper, or with the red and yellow fabrics made for photographic purposes.

Prices of Photographic Equipment are as follows:

Eastman folding pocket kodak No. 3, with double combination, rapid rectilinear lens, ball bearing shutter, and rising and sliding front	$17.50
Black sole leather case with strap	1.75
Film cartridge, 6 exposures, 3¼x4¼	.35
Film cartridge, 12 exposures, 3¼x4¼	.70
Empire State camera, 8x10, including 1 plate holder and canvas carrying case	28.00
No. 2 Goerz Dagor lens	51.50

PRICES OF PHOTOGRAPHIC EQUIPMENT—Continued

No. 5 Goerz Dagor lens	91.00
X excel Sector shutter for No. 2 lens, which is dust tight and will speed up to 1/150 second	17.00
Same for No. 5 lens	20.00
5 Extra plate holders, @ $1.25	6.25
1 No. 2 Crown tripod, 6-inch top	7.50
Cramer isochromatic plates, per dozen	1.85
Velox paper, 3¼x4¼, per dozen 15c; gross	1.50
Velox paper, 8x10, per dozen 80c; gross	9.00
2 Hard rubber trays, 8½x10½ for plates, at $1.80	3.60
Universal hard rubber fixing bath	5.50
1 4 Ounce tumbler graduate glass	.15
1 16 Ounce tumbler graduate glass	.30
½ Dozen 32 ounce, wide mouth bottles, with cork stoppers, @ 12c	.72
Zinc washing box for plates	2.00
3 Hard rubber trays, 5x7, for films, @ $1.00	3.00
1 Printing frame, 8x10	.75
1 Printing frame, 3¼x4¼	.40
1 Dozen photo clips	.15
1 Small ruby lamp	1.25

It is not necessary to buy trays; wooden boxes lined with oil-cloth are all that are necessary.

For much of the data in the foregoing article I am indebted to Mr. A. A. Russell of Flushing, L. I.

There is an excellent article in *Engineering News,* Nov. 19, 1908, page 552, on "Industrial Photography," by S. Ashton Hand.

PICKS AND MATTOCKS

Net prices at Chicago for picks and mattocks, in quantities are as follows:

RAILROAD OR CLAY PICKS.

Weight, Lbs.	Price, Each.	Price, Per Doz.
7½	$0.52	$5.23
8½	.54	5.54

The above have adze eye, pick and chisel points, and are made of high grade solid steel. The points are made of crucible tool steel.

STANDARD DIRT PICKS.

Weight, Lbs.	Price, Each.	Price, Per Doz.
5 to 6	$0.32	$3.15
6 to 7	.34	3.37
7 to 8	.36	3.60
9 to 10	.45	4.50

DRIFTING PICKS.

Weight, Lbs.	Price, Each.	Price, Per Doz.
4½	$0.38	$3.85
6	.45	4.57

These drifting picks have adze eye and the points are of the best grade of crucible tool steel.

MATTOCKS (ADZE EYE).

	Weight, Lbs.	Size Blade, Ins.	Size Cutter, Ins.	Price, Each.	Price, Doz.
Short cutter	5	3½x7½	2½x4¼	$0.36	$3.60
Long cutter......	5½	3½x7½	2½x5¼	.36	3.60

Pick mattocks, weighing 5½ lbs., with a blade 4⅛x8½ ins. and a cutter 8½ ins. can be bought at a net price of $4.25 per doz.

Asphalt Mattocks. The net prices for asphalt mattocks in quantities, at Chicago, are as follows. For a mattock with crucible steel cutter and chisel ends, weighing 9 lbs., the cost is 90 cts. each, or $9 per doz. A mattock with double cutter, weighing 8 lbs., can be bought for 60 cts. each, or $6 per doz.

PIER AND FOUNDATION PLANT

PIERS AND FOUNDATIONS FOR THE CHICAGO, MILWAUKEE & PUGET SOUND RY. BRIDGE CROSSING THE COLUMBIA RIVER.*

The bridge crosses the Columbia River about 420 miles from its mouth. At this point the river has a width at low water of 1,050 ft., at average high water of 2,800 ft., and at extreme high water of 4,500 ft. The bridge is 2,898.84 ft. long; its approaches are timber trestle on concrete pedestals and are 1,315.58 ft. and 323.58 ft. long respectively. The principal dimensions of the piers are given in Table I. All piers have a batter of ½ in. to 1 ft. on the sides and downstream end of 3 ins. to 1 ft. on the cutwaters. The footings vary in width from 13 to 32 ft. and in length from 32 to 60 ft.

TABLE I.—TOTAL COST OF THE PIERS, DISTRIBUTING ALL GENERAL AND INCIDENTAL EXPENSES.

Pier	Width under coping	Length under coping	Height overall	Cu. yds. of concrete	Total cost	Cost per cu. yd. of concrete
"A"	6′ 6″	25′ 6″	34.8′	290	$ 5,458.62	$18.82
1	8′ 0″	30′ 5⅛″	39.1′	500	9,933.79	19.84
2	8′ 0″	30′ 5⅛″	39.0′	498	9,709.65	19.40
3	8′ 0″	30′ 5⅛″	39.1′	500	9,644.64	19.29
4	8′ 0″	30′ 5⅛″	38.5′	490	11,391.38	23.25
5	8′ 0″	30′ 5⅛″	39.2′	503	10,953.16	21.77
6	8′ 0″	30′ 5⅛″	40.1′	572	11,692.62	20.44
7	8′ 6″	31′ 7⅜″	43.3′	622	16.369.79	26.32
8	9′ 0″	32′ 9½″	59.6′	1,404	42,792.03	30.48
9	9′ 0″	32′ 9½″	64.0′	1,506	42,283.20	28.07
10	10′ 0″	30′ 1″	91.0′	2,363	58,078.26	24.58
11	10′ 0″	30′ 1″	92.4′	2,452	63,925.50	26.07
12	8′ 6″	31′ 7⅜″	41.0′	584	13,328.93	22.82
13	8′ 0″	30′ 5⅛″	41.5′	528	11,139.24	21.09
14	8′ 0″	30′ 5⅛″	38.5′	487	9,685.11	19.89
"B"	6′ 6″	25′ 6″	29.4′	240	5,133.13	21.38
Total				13,539	$331,519.05	$24.49

For 12 land piers, 5.814 cu. yds.; an average cost per cu. yd. of concrete..$21.40
For 4 river piers, 7.725 cu. yds.; average cost per cu. yd. of concrete.. 26.81

*Condensed from a paper by R. H. Ober, before the Pacific Northwest Society of Engineers. Proceedings Vol. IX, No. 3, December, 1910.

Transporting Construction Materials. About 14,000 tons of material and supplies were required for the construction of the bridge substructure and of the line near the river. The cost of freighting material across country by wagon from the nearest railroad, a distance of about 35 miles, was estimated at $12 per ton. This cost and the character of the service, with its delays and uncertainties, made this impracticable, and it was determined to handle all freight by river if possible. Navigation between the site of the bridge and a supply point on the river below the Cabinet Rapids, about one-half mile from Vulcan Station on the Great Northern R. R. and 8 miles below the Great Northern bridge, was considered to be practicable for light draft river steamers. Arrangements were made for the construction of a stern wheel river steamer of the type generally used on the upper Columbia River, and the steamer St. Paul was built at Trinidad and placed in commission on October 30, 1906. The principal dimensions of the steamer are as follows:

Length of hull	115 ft.
Beam	22 ft. 6 in.
Beam over guards	25 ft.
Draft light, about	18 in.
Draft loaded, about	3 ft.
Gross tonnage, about	200 tons
Actual freight capacity	112 tons
Engines, high pressure, non-condensing, with cylinders 10 inches diameter, 48 inches stroke, boiler pressure	200 lbs.

This steamer cost about $11,000 to build and was used not only for handling materials and supplies but also for towing and tending at the bridge, handling barges, etc. The operating expense for a period of about 27 months was as follows:

Fuel	$10,200
Wages of crew and charter of steamer	28,800
Total	$39,000

The cost of unloading and handling freight from the cars at Vulcan to the steamboat landing, about one-half mile distant, by wagon, was about $2 per ton. The cost of handling by steamer from Vulcan to the bridge, a distance of about 36 miles, ranged from about $1 to $4 per ton, varying at different stages of the river, averaging approximately $1.80 per ton, making the cost of freight from the cars to the bridge about $3.80 per ton.

Contract. A contract was entered into, on a percentage basis, for the construction of the substructure and trestle approaches, and for the erection of the falsework for the superstructure.

Under this contract the contractor furnished all tools, outfit, machinery and equipment necessary for the doing of the work, with the exception of equipment of a nature not generally used by the contractor and of a character peculiarly required by the nature of the work to be done, which latter equipment was fur-

nished by the railway company. The plant furnished by the contractor included the following:

6	hoisting engines.
5	stationary engines.
1	rock crusher and engine.
2	concrete mixers.
2	eight-inch centrifugal pumps.
2	six-inch centrifugal pumps.
4	steam pumps.
3	steam boilers, 40, 60 and 80 h. p.
2	steam drills.
6	derricks.
2	pile drivers.
1	steam hammer.
1	electric light engine and dynamo.
12	dump cars, 1½ cu. yds.
6	flat cars.
11,000	feet steel rails.
12	steel hoisting buckets.
5	skips.
2	orange-peel dredges.
1	clam-shell dredge.
37	coils of Manila rope.
10,000	lineal feet of ½" wire rope.
14,000	lineal feet of ⅝" wire rope.
12,700	lineal feet of ¾" wire rope.
900	lineal feet of 1" wire rope.
	Small tools and fittings as required.

The total value of this plant was approximately $48,000.

PILE DRIVERS

There are three types of pile drivers:

1. Free fall, in which the hammer is detached from the hoisting rope and allowed to fall freely upon the pile.
2. Friction clutch, in which the hammer remains always attached to the hoisting rope, and by means of a friction clutch on the hoisting engine the drum is thrown into gear or out of gear at will.
3. Steam hammer or pile hammer, which is described under that heading.

A free fall hammer strikes about 7 blows a minute when the fall is 20 ft. and a hoisting engine is used. A friction clutch strikes about 18 blows per minute when the fall is 12 ft., and 25 blows per minute when the fall is 5 ft. A steam hammer strikes about 300 blows per minute. A railway pile driver is a heavy driver of the overhanging type, mounted on a flat car, either drawn by an engine or self propelled. Similarly, a scow pile driver is a pile driver mounted on a scow. A scow pile driver will drive more piles per day than a railway pile driver because there is no delay engendered by the sawing off and capping of each pile in order to allow the machine to pass over it.

Pile drivers range in height from 30 ft. up; the highest pile driver in the world in 1908 was one 108 ft. high.

A large pile driver traveling on a track was used by the government on the Columbia River Improvement. Its equipment consisted of boilers and engines for hoisting a 5,700 pound hammer and of boilers, pumps, etc., for operating a water jet. The machine had a reach on each side of 30 ft. and the height of leads above the cut-off of the piles was 80 ft. The largest pile which the leads would take was 26 inches in diameter and piles up to this size were driven by using the hammer in combination with the water jet. Piles 30 inches in diameter were driven by resting the hammer on their edges and driving with the jet. Piles as long as 150 ft. were driven on this work. The total weight of the machine was 60 tons and its cost about $12,000.

The Louisville & Nashville R. R. Co. used a railway pile driver of their own make. Mr. G. W. Hinman gave the cost of operation per day as follows:

Foreman and 10 men	$22.00
Engineer, fireman and watchman	6.80
Conductor and 2 flagmen	7.00
Coal, oil and waste	2.50
Use of locomotive	12.00
For use of driver and tools	2.50
Total	$52.80

The above crew was used for building short trestles, say of 30 to 40 piles. When longer trestles were built a larger crew proved more economical because of fewer delays to trains. This pile driver was also used as a derrick and material of all kinds was unloaded with it.

Mr. Aron S. Markley said that the Chicago & Eastern Illinois Railway used a Bay City pile driver. This was self-propelling and made about 8 miles per hour under its own steam. It was able to haul 5 or 6 cars on a level grade. When the pile driving was done within 1½ miles of a side track an engine was rarely used to haul it. The operator was paid $2.50 per day. The hammer weighed 2,800 lbs., and the original cost of the entire machine was $4,500. Very few repairs were necessary; the chains and sprockets being about the only parts which needed renewing, and they had a life of from 1 to 1½ years. The machine, when working, drove from 40 to 50 piles per day.

Pile drivers mounted on sills for operation by a steam engine cost as follows:

Price complete without blocks, lines or engine:

Size of Driver, Pounds.	Width of Jaws, Inches.	Distance Between Jaws, Inches.	Price of Hammer.	Height of Leads, Feet.	Total Price Iron Work.	Woodwork Complete Short Sills.	Total Price, Complete.	Extra for Extension Sills.
1,500	6¼	18	$36.00	30	$ 86.00	$135.00	$220.00	$22.00
1,800	6¼	18	45.00	30	93.00	135.00	230.00	22.00
2,000	7¼	19	48.00	35	111.00	175.00	285.00	27.00
2,500	7¼	19	58.00	40	148.00	235.00	360.00	27.00
3,000	8¼	20	66.00	50	155.00	430.00	590.00	40.00

Pile drivers mounted on sills are usually operated by horse power. When so operated the hammer on the small sizes is raised direct; on the large ones the end of a line is fastened to a post or other deadman, carried through a tackle block on the main hoisting line, and tied to the whiffle trees. Winches, bolted to the ladder, can be used to raise the hammer but are very slow. Prices complete without blocks, lines or engine, are as per table on following page.

SIZES AND COSTS OF PILE DRIVERS ON SILLS.

(Prices without blocks, lines, or engines.)

Size of Driver, Pounds.	Width of Jaws, Inches.	Distance Between Jaws, Inches.	Price of Hammer.	Height of Leads, Feet.	Price of Iron Work.	Price of Wood-work.	Total Price, Complete.	Duty—Size of Piles or Piling Hammer Will Drive.
500	4¼	13	$15.00	24	$52.00	$ 84.00	$136.00	2"x12" sheeting
600	4¼	13	18.00	24	54.00	84.00	139.00	2"x12" sheeting
700	4¼	14	20.00	26	57.00	100.00	158.00	3"x12" sheeting
800	4¼	14	23.00	26	60.00	100.00	161.00	3"x12" sheeting
1,000	5¼	16	25.00	28	77.00	112.00	190.00	4"x12" sheeting
1,200	5¼	16	31.00	28	82.00	112.00	195.00	4"x12" sheeting
1,500	6¼	18	37.50	..	.....	......	......	10" square or round piles
1,800	6¼	18	45.00	..	.....	......	......	12" square or round piles
2,000	7¼	19	50.00	..	.....	......	......	14" square or round piles
2,500	7¼	19	62.50	..	.....	......	......	18" square or round piles
3,000	8¼	20	75.00	..	.....	......	......	Heavy concrete piles

Adjustable trips, for regulating the length of stroke, cost:

For hammer of 2,500 lbs. and over	$18.50
For hammer of 1,200 to 2,000 lbs.	12.75
For hammer of 1,000 lbs. and under	10.00

A small pile driver 30′ high with a hammer head weighing 2,200 lbs. was constructed at the following cost. Bill of lumber for the driver is as follows:

			Ft. B. M.
2 Pieces	4″x 6″x30′	(leads)	120
1 Piece	6″x 6″x 4′	(cross-piece)	12
2 Pieces	6″x 6″x16′	(base)	96
2 Pieces	2″x 4″x32′	(ladder)	43
2 Pieces	2″x 4″x 2′	(ladder rungs)	24
1 Piece	4″x 4″x26′	(sway braces)	64
1 Piece	2″x 4″x20′	(long front sill)	13
1 Piece	2″x 4″x14′	(short rear sill)	3
1 Piece	12″x12″x 4′	(drum)	48
30 Pieces	1″x12″x 6′	(bull wheel)	180
Total			603

Two carpenters and two laborers built this driver in two days, total cost was:

700 Feet B. M. at $20.00	$14.00
Bolts and nails	2.00
Labor	18.00
1,200-lb. Pile hammer	50.00
1 Pair nippers	5.00
1 Snatch block	3.00
240 Feet of 1-in. rope	10.00
Total	$102.00

The City of Chicago in 1901 constructed some intercepting sewers by day labor. Wakefield sheet piling 2x12 in. x 20 ft., Norway and Georgia pine lumber, surfaced one side and one edge, was used. It was found that Norway pine would stand about 50 per cent more blows under a drop hammer. The city built with its own labor a turntable drop hammer pile driver. The hammer weighed 3,000 lbs. The driver was equipped with a 7x10 inch double-drum hoisting engine and a duplex steam pump for jetting. The leads were 40 ft. long. It cost $2,200. In operation it was found practical to swing the driving apparatus about once each day. In ordinary driving the crew averaged 90 pieces of sheeting in 8 hours, which is equivalent to 45 ft. of trench. The pile driving crew consisted of 13 men costing $40.66 per day, which gives a cost of 90 cts. per ft. of sewer. The bill of material required for 90 ft. of piling was as follows:

10.8 M., B. M., 2x12-inch x 20-foot timber, @ $22.00	$237.60
900 50 D Spikes, @ $2.65 per 100	23.85
1 Ton of coal for pile driver	2.90
Total	$264.35

This gives a cost of $5.87 per ft. of trench, or a total cost of $6.77 per ft.

During the six months ending June 30, 1910, the cost of repairs

to all pile drivers on the Panama Canal work was an average of $9.42 per day for 442 days of work.

The pile drivers used on the work of improving Lincoln Park, Chicago, during 1910 and 1911, were of the drop hammer type,

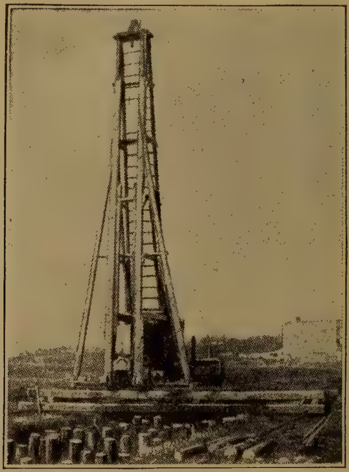


Fig. 191. Special Traveling Pile Driver.

equipped with 45 ft. leads and 2,400-lb. hammers. The cost of operation of Driver No. 1 during 1910 was as follows:

Hours in commission	768
Labor operation	$2,629.70
Fuel and supplies	485.90
Labor repairs	515.78
Towing, 4½ hours, @ $2.72	12.24
Insurance	85.00
Total cost	$3,728.62
Cost per hour	4.74

The cost of operation and repairs on Drivers No. 1 and No. 2 during 1911 are here given. The extensive repairs, including a new deck house and a new boiler to fit driver No. 2 for work, accounts for the high repair cost for that machine.

COST OF OPERATION AND REPAIRS OF PILE DRIVER NO. 1

Hours in commission		1,135
Labor	$4,962.22	$4.37
Fuel	215.65	.19
Supplies	325.80	.29
Watching	225.04	.20
Insurance	79.20	.07
	$5,807.91	$5.12

Repairs:		
Labor	$ 550.28	$0.48
Material	194.04	.17
	$ 744.32	$0.65
Total operation and repairs	$6,552.23	$5.77

COST OF OPERATION AND REPAIRS OF PILE DRIVER NO. 2.

Hours in commission		634
Operation:		Per hour.
Labor	$2,771.85	$4.37
Fuel	126.80	.20
Supplies	184.77	.29
Watching	132.30	.21
Insurance	79.20	.13
	$3,294.92	$5.20
Repairs:		
Labor	$1,237.89	$1.95
Material	676.57	1.06
Derrick	60.58	.10
	$1,975.04	$3.11
Total operation and repairs	$5,269.96	$8.31

Steam or Air Hammer. The principle of operation is the alternate rapid rising and driving down of a ram of considerable weight, by steam or compressed air. It gives a lighter blow than the drop pile hammer, but its blows follow each other so rapidly that the pile and the ground do not have time to settle back into their normal static condition before the next blow strikes the pile. It does not split or broom the pile head as much as the drop hammer does, and it holds the pile more steady.

The hammer illustrated in Fig. 192 can be suspended in the leads of a pile driver or hung from a derrick, crane or beam. Table 127 gives the sizes, weights, prices, etc., including fittings for attaching hose to hammer but no hose. Hose costs as follows:

Size, Inches.	Number of Plies.	Price per Foot.
¾	5	$0.48
1	5	.60
1¼	6	.90
1½	6	1.08
1¾	6	1.30
2	7	1.74

Another make of hammer is as follows:

For Piling.	Weight, Lbs.	Air Consumption, Cu. Ft. per Min.	Boiler Pressure, Lbs.	Boiler H. P.	No. of Blows per Minute.	Stroke, Ins.	Piston, Ins.	Length.	Price.
2″	139	100	75-80	8-10	400	3¾	2¼	3′ 6″	$200
4″	628	150	75-80	12-15	325	5¾	3¼	4′ 6″	300

The driving cap for steel piling costs $10 extra.

TABLE 127.—STEAM OR AIR PILE HAMMERS.

Size No.	Total Weight, Pounds.	Weight of Ram, Pounds.	Dimensions Over All —Height, Width, Depth—Inches.	Cylinder Diameter & Stroke, Inches.	Total Downward Force Steam Ram, Lbs.*	No. of Strokes per Minute.	Power, Foot Lbs. per Minute.	Steam Boiler H. P. Required 80 Lbs. Pressure per Sq. In., Approximate.	Comp. Air, Free Air per Min., 80 Lbs. Pressure per Sq. In., Approximate.	Suitable for	Size of Hose, Inches.	Width Required Between Leaders, Inches.	Price.
1	7,500	1,500	80x29x15	9½x21	5,754	110	1,107,700	30	600	Heavy work, 14" to 18", round or square	1¾	30	$900.00
2	5,000	800	72x25x13	7¼x16	3,278	130	568,000	18	300	General work, 10" to 14", round or square and steel piling	1½	26¼	700.00
3	4,200	550	64x23x12	6¼x14	2,392	125	376,000	15	200	Minor work, 8" to 10", round or square steel piling and wood sheeting	1¼	24	650.00
4	2,600	350	57x20x10½	5¼x12	1,646	150	247,000	10	150	Sheet piling, 6"x12" small round piles, steel piling	1¼	21	550.00
5	1,400	200	46x17x 9	4¼x 9	1,052	200	157,800	8	100	Sheet piling, 4"x8" and 3"x12" steel piling	¾	18¼	430.00
6	850	100	38x14x 7¼	3¼x 7	598	250	87,500	5	60	Sheet piling, 2"x6" to 12" and 3"x8", light steel sheeting	¾	15	350.00
7	400	50	30x10x 6	2⅜x 5¼	....	300	....	4	55	1" Sheet piling	¾	..	250.00

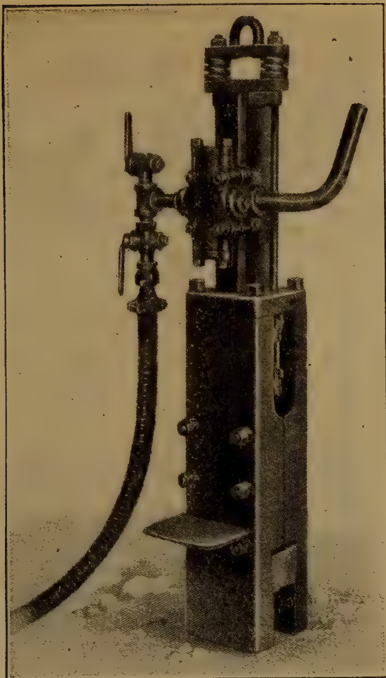


Fig. 192. Steam or Air Pile Driver for 3-Inch Sheet Piling.

*Referring to downward force in table on preceding page, the duty of hammers is usually given in "wood" units; the sheet steel piling equivalents are as follows:

Hammers driving 2"x12" sheeting will drive 9" sheet steel piling to 20′ penetration.
Hammers driving 3"x12" sheeting will drive 12" sheet steel piling to 20′ penetration.
Hammers driving 4"x12" sheeting will drive 12" sheet steel piling to 25′ penetration.
Hammers driving 14" round piles will drive 12" sheet steel piling to 40′ penetration.
Hammers driving 18" round piles will drive 15" sheet steel piling to 60′ penetration.

PILING

Hardwood piles are used where the driving is difficult and the soft varieties where it is easy. In 1910 in New York and the North Central States the price was about as follows. Spruce or yellow pine, 12x6 inches, 30 to 35 ft. long, 10 to 11 cts. per ft.; spruce, 40 to 45 ft. long, 11 to 12 cts.; short leaf yellow pine, 50 ft. long, 15 cts.; same 60 ft. long, 15 to 16 cts.; long leaf, 50 ft. long, 17 to 22 cts.; 60 ft. long, 18 to 23 cts.; oak, 18 to 22 cts.; scrub oak, short lengths and odd sizes, 10 cts. and up. The charge for driving a pile in the vicinity of New York is about $3.00.

Pile points, or shoes, with 4 straps cost: Square, each 95 cts. to $1.40; oblong, each $1.05 to $1.50; round of 6-in. diameter, each $1.40; 8-in., each $2.75; 10-in., each $4.25. Pile bands to prevent brooming are made of 1-in. iron, 2 to 4 ins. wide and cost from $2.00 to $4.00 each.

Cost of piling and piles in the construction of an ore dock for the Duluth & Iron Range R. R., is abstracted from an article by Leland Clapper, in *Engineering and Contracting,* July 17, 1912.

The following tables give the time of the various classes of labor and of the outfits used in carrying out different parts of the work. The time allowed for outfit includes only the time while actually in use. A 40 H. P. gasoline boat did most of the towing and the time of its engineer is included in the tables.

In Table I for sheet piling, the item "preparing and handling" includes spiking on the tongues and grooves, using about 50 ⅜x8-in. spikes per pile, also sharpening, loading by derrick from skidway to scow, and unloading at the drives. The item "waling and tying" covers the placing of the temporary inside guide timbers, the temporary outside waling timbers and all temporary and permanent bolts and anchors.

I.—TIME COST OF SHEET PILING (2,350 PILES).

	Hours.	Hours per 100 Sheet Piles.
Preparing and Handling:		
Foreman	370	15.58
Carpenters	520	21.89
Skilled labor	1,630	70.73
Common labor	4,950	208.40
Engineer	340	14.31
Tug and crew	40	1.68
Derrick scow	250	10.53
Driving:		
Foreman	590	24.84
Skilled labor	1,890	79.57
Common labor	2,160	90.94
Engineer	830	34.94
Drivers	570	24.00
Cutting Off:		
Common labor	1,700	71.57
Waling and Tying:		
Foreman	760	32.00
Carpenters	2,380	100.20
Skilled labor	6,330	266.49
Common labor	13,370	562.88
Engineer	1,960	82.52
Tug and crew	40	1.68
Derrick scow	1,040	43.78
Drivers	570	24.00

Table II for round piles includes only those piles in the dock proper. The item "pointing and handling" includes sorting, pointing, rafting and delivering to drivers. The cutting includes the removing of the old pile heads.

II.—TIME COST OF ROUND PILE WORK (163,500 PILES).

	Hours.	Hours per 100 Lin. Ft.
Pointing and Handling:		
Foreman	20	.0122
Engineer	350	.2135
Skilled labor	2,330	1.4213
Common labor	2,390	1.4579
Derrick scow	130	.0793
Team	350	.2135
Driving:		
Foreman	670	.4087
Engineer	670	.4087
Skilled labor	2,670	1.6287
Common labor	2,690	1.6409
Pile driver	660	.4026
Cutting Off Piles:		
Foreman	130	.0793
Skilled labor	600	.3660
Common labor	3,180	1.9398

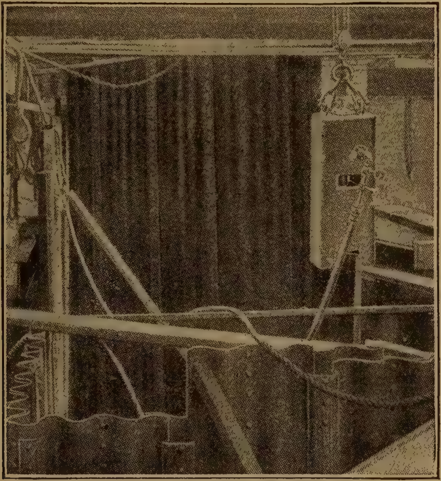


Fig. 193. No. 5 Hammer Driving Wemlinger Piling.

The standard dovetailed sheet-piling of the Southern Pacific Railway used by Mr. Kruttschmitt in closing breaks on the Mississippi levees, is described as follows in the *Reclamation Record.*

"The main body of each pile is composed of a 4x12-in. plank with the lower end adzed to a slope of about 15 degrees with

the horizontal, so as to force the piling in driving against the preceding one. On one edge of the body is nailed two strips made of 1-in. boards, having their exterior edges in the plane of the face of the pile, and their interior edges beveled so as to form a trapezoidal groove between them with a larger base adjacent to the body of the pile. This larger base is made about 2 inches in length, the shorter base about 1 inch in length. On the other edge of the main body of the pile is nailed a single strip made of 1-in. boards and so beveled as to permit it to slip snugly between the beveled opening on the adjacent pile. The strips are nailed to the main pile with 10d wire nails spaced 6 ins."

The cost of making 1 sq. ft. of this piling would be about as follows:

1 4"x12"x12" plank at $30 per M., B. M.	$0.12
3 2"x 1"x12" planks at $30 per M., B. M.	.015
6 10d wire nails at $2.20 per keg	.002
¼ hour of carpenter at 50 cents per hour	.125
Total	$0.262

Wemlinger Sheet Steel Piling illustrated in Fig. 193 costs, f. o. b. New York, as follows:

WITH SHORT CLIPS.

Type.	Thickness.	Price per Sq. Ft.	Extra per Clip.
1-A	1/16"	$0.24	$0.14
2-A	7/64"	.28	.15
3-A	⅛"	.29	.16
4-B	7/64"	.285	.16
5-B	⅛"	.32	.17
6-B	5/32"	.34	.18
7-B	3/16"	.37	.19
8-C	3/16"	.42	.20
9-C	¼"	.45	.21
10-C	5/16"	.55	.22

WITH FULL LENGTH CLIPS.

Type.	Thickness.	Price per Square Foot, Including Clip.
11-B	7/64"	$0.34
12-B	⅛"	.36
13-B	5/32"	.39
14-B	3/16"	.42
15-C	3/16"	.48
16-C	¼"	.54
17-C	5/16"	.62
18-D	3/16"	.64
19-D	¼"	.73
20-D	5/16"	.87

Wakefield Piling is suitable for light or medium heavy work. It has been used with great success on small sewers. The special cap necessary for use in driving costs $10.

The cost of Wakefield sheeting complete and ready for driving for Lincoln Park improvement, Chicago, 1911, was as follows:

		Per piece.
1,784 Pieces 6-in. Sheeting, 24 ft.		
Labor	$1,682.31	$0.94
Hardware	115.96	.07
Lumber	7,457.12	4.18
Total	$9,255.39	$5.19
200 Pieces 6-in. Sheeting, 28 ft.		
Labor	$ 188.60	$0.94
Hardware	130.00	.07
Lumber	974.00	4.87
Total	$1,292.60	$5.88
94 Pieces 9-in. Sheeting, 12 ft.		
Labor	$ 88.36	$0.94
Hardware	8.74	.09
Lumber	294.22	3.13
Total	$ 391.32	$4.16
105 Pieces 9-in. Sheeting, 14 ft.		
Labor	$ 98.70	$0.94
Hardware	9.45	.09
Lumber	383.25	3.65
Total	$ 491.40	$4.68
428 Pieces 9-in. Sheeting, 18 ft.		
Labor	$ 402.32	$0.94
Hardware	38.52	.09
Lumber	2,011.60	4.70
Total	$2,452.44	$5.73
1,742 Pieces 9-in. Sheeting, 24 ft.		
Labor	$1,637.48	$0.94
Hardware	156.78	.09
Lumber	10,922.34	6.27
Total	$12,716.60	$7.30
200 Pieces 9-in. Sheeting, 28 ft.		
Labor	$ 188.00	$0.94
Hardware	18.00	.09
Lumber	1,462.00	7.31
Total	$1,668.00	$8.34
Total cost of 4,553 pieces		$28,267.75

Summary:

Total cost of labor	$ 4,285.77
Total cost of hardware	477.45
Total cost of lumber	23,504.53
	$28,267.75

Lackawanna Steel Piling, illustrated in Fig. 194, costs, f. o. b. cars Pittsburgh, about 1.5 cents per lb. It comes in any length up to 70 ft. and its other dimensions are as follows:

Thickness of Web, Ins. A	Weight per Square Foot of Wall, Lbs.	Dist. Center to Center of Joints, Ins. B	Weight per Lineal Foot, Lbs.	Width of Joint Over All, Ins. C
½	40.00	12¾	42.500	3 45/64
⅜	35.00	12¾	37.187	3 45/64
¼	21.50	7	12.54	1 53/64

This piling drives easily. In a test a 50-ft. length was driven 47 ft., under a 5-ton hammer striking 90 blows, with a penetration of 1 inch at the last blow.

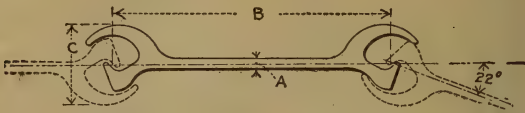


Fig. 194. 12¾-Inch Piling, ⅜-Inch and ½-Inch Web.

TEST OF DRIVING STEEL SHEET PILING, CLEVELAND, O.

One place on the short line of the L. S. & M. S. R. R. around Cleveland, Ohio, required tunneling under the grounds of a manufacturing plant. The tunnel was to have two standard grade tracks at an elevation of about 50 ft. below yard level of this plant. The wash test borings taken at this point showed:

Below Grade	
Yard level to 5 ft.	Slag and cinders.
5 ft. below to 20 ft.	Yellow clay and gravel.
20 ft. below to 30 ft.	Fine gravel.
30 ft. below to 40 ft.	Coarse gravel.
40 ft. below to 50 ft.	Fine sand.
50 ft. below to 55 ft.	Coarse sand and gravel.
55 ft. down	Hard pan (blue clay).

The fine sand, 40 to 50 ft., was in the nature of quicksand, and there was a surcharged load at the sides.

The engineers of the Lake Shore R. R. decided on steel sheet piling. This work required 60 ft. penetration. Five bars of 12¾-in. x ½-in. Lackawanna steel sheet piling, weighing 40 lbs. per sq. ft. and 50 ft. long were ordered for this test. These bars were driven by a No. 1 Vulcan hammer, weighing 10,150 lbs., total striking part 5,000 lbs. with a 42-in. stroke. In general the record was as follows:

No. 1 Pile (experimenting, etc. Accurate record not taken.)

	Blows
No. 2 Pile 20 min. actual driving time	1,136
No. 3 Pile 23⅙ min. actual driving time	1,572
No. 4 Pile 35 min. actual driving time	2,284
No. 5 Pile 20¼ min. actual driving time	1,283

No. 5 pile was followed down to 10 ft. below the surface of the ground in 18⅝ minutes, with 1,153 blows. All five bars were driven to the surface of the ground, making a penetration of 50 ft.

Jones & Laughlin Piling, illustrated in Fig. 195, costs about 1.5 cts. per lb., f. o. b. Pittsburgh. It is made in any length.

No.	Size (Ins.)	Wt. per Sq. Ft. (Lbs.)
1	12x5	35.00
2	12x5	36 25
3	15x6	37.20
4	15x6	39.75
5	15x6	42.25

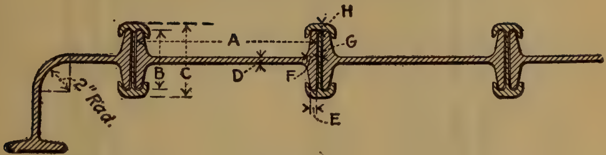


Fig. 195.

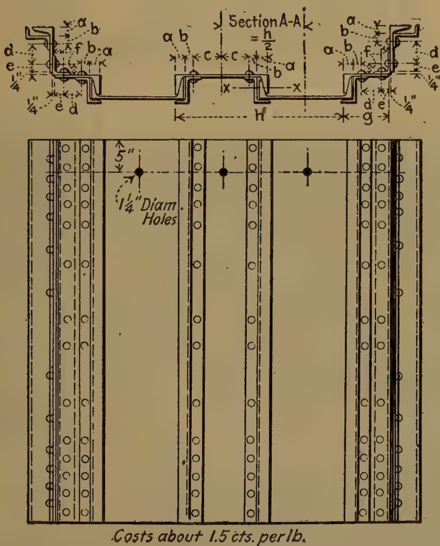
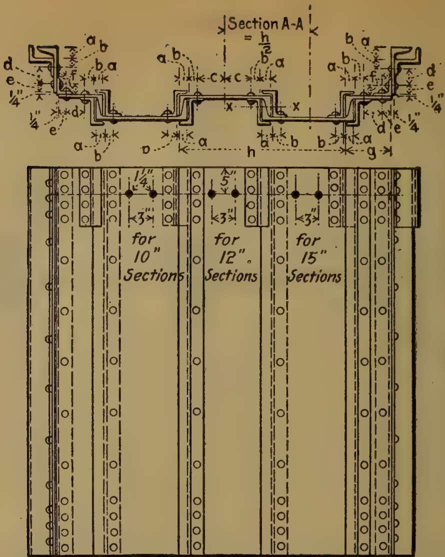


Fig. 196.



Costs about 1.5 cts. per lb.

Fig. 197.

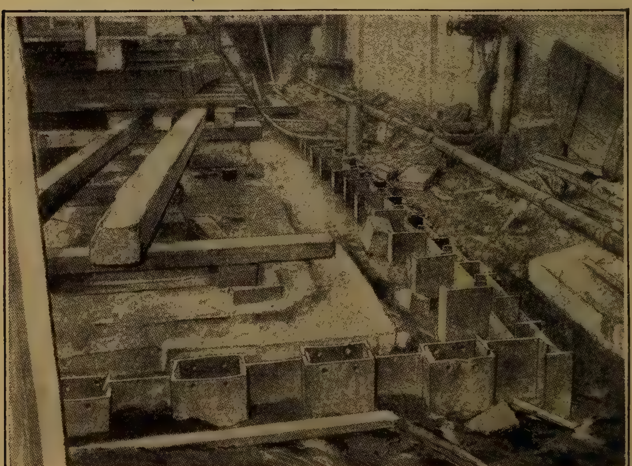


Fig. 198. Interior View of Chicago Avenue Pumping Station, Showing Interlocking Steel Sheeting Driven Alongside of Pumps Which Were in Continuous Operation.

PRIESTEDT INTERLOCKING CHANNEL BAR PILING.

COMPOSITION AND DIMENSIONS OF SECTIONS.

No.	Description	Channels Ins.	Channels Lbs. per Ft.	Zees Ins.	Zees Lbs. per Ft.	Corner Angles Ins.	a Ins.	b Ins.	c Ins.	d Ins.	e Ins.	f Ins.	g Ins.	h Ins.
1	12"x33 lbs.	12	20.5	3 5/8 x 3/8	8.6	2 1/2 x 2 1/2 x 3/8	1 3/8	1 1/4	3 3/8	2 1/4	1 1/8	1 3/8	6	21 3/4
2	12"x38 lbs.	12	25	3 5/8 x 3/8	8.6	2 1/2 x 2 1/2 x 3/8	1 3/8	1 1/4	3 3/8	2 1/4	1 1/8	1 3/8	6	21 3/4
3	15"x38 lbs.	15	33	4 1/8 x 3/8	9.2	3 x 3 x 3/8	1 11/16	1 5/16	4 1/2	3	1 1/2	1 3/4	7 1/2	27
4	15"x44 lbs.	15	40	4 1/8 x 3/8	9.2	3 x 3 x 3/8	1 11/16	1 5/16	4 1/2	3	1 1/2	1 3/4	7 1/2	27

SYMMETRICAL INTERLOCK CHANNEL BAR PILING.

COMPOSITION AND DIMENSIONS OF SECTIONS.

No.	Description	Channels Ins.	Channels Lbs. per Ft.	Zees Ins.	Zees Lbs. per Ft.	Corner Angles Ins.	a Ins.	b Ins.	c Ins.	d Ins.	e Ins.	f Ins.	g Ins.	h Ins.
1	10"x28 lbs.	10	15	3 1/8 x 1/4	4.8	2 1/4 x 2 1/4 x 1/4	1 1/16	15/16	3	2	1	1 1/4	5	18
2	10"x34 lbs.	10	20	3 1/8 x 1/4	4.8	2 1/4 x 2 1/4 x 1/4	1 1/16	15/16	3	2	1	1 1/4	5	18
3	12"x34 lbs.	12	20.5	3 5/8 x 3/8	8.6	2 1/2 x 2 1/2 x 3/8	1 3/8	1 1/4	3 3/8	2 1/4	1 1/8	1 3/8	6	21 3/4
4	12"x39 lbs.	12	25	3 5/8 x 3/8	8.6	2 1/2 x 2 1/2 x 3/8	1 3/8	1 1/4	3 3/8	2 1/4	1 1/8	1 3/8	6	21 3/4
5	15"x39 lbs.	15	33	4 1/8 x 3/8	9.2	3 x 3 x 3/8	1 11/16	1 5/16	4 1/2	3	1 1/2	1 3/4	7 1/2	27
6	15"x45 lbs.	15	40	4 1/8 x 3/8	9.2	3 x 3 x 3/8	1 11/16	1 5/16	4 1/2	3	1 1/2	1 3/4	7 1/2	27

UNITED STATES STEEL SHEET PILING.

Costs about 1.5 cts. per lb.

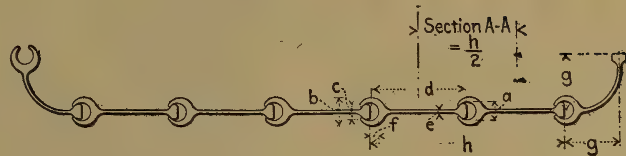


Fig. 199.

COMPOSITION AND DIMENSIONS OF SECTION.

No.	Description.	Weight per foot, pounds.	a—Inches.	b—Inches.	c—Inches	d—Inches.	e—Inches.	f—Inches.	g—Inches.	h—Inches.	Straight Section.	Regular Corner.
1	12"x40 lbs.	40	2 9/16	3 21/32	2	12 1/32	½	1 9/32	7	24 1/16	40 lbs. per sq. ft.	40 lbs. per lin. ft.
2	12"x35 lbs.	35	2 9/16	3 21/32	2	12 1/32	⅜	1 9/32	7	24 1/16	35 lbs. per sq. ft.	35 lbs. per lin. ft.
3	6"x11 lbs.	11	1¼	1 15/16	1 3/32	5⅞	¼	11/16	3¼	11 13/16	22 lbs. per sq. ft.	11 lbs. per lin. ft.

The Bush Terminal Co. of Brooklyn, N. Y., decided in 1910 to substitute steel for wood sheet piling in the construction of the foundation pits of their new buildings. Each of the 288 reinforced concrete columns in these buildings requires the digging of a foundation pit 10 ft. x 12 ft. x 12 ft. deep. In excavating some of the first of these pits, the sheeting was of 2x10-in. wood piling which cost $1.00 per horizontal foot, including rangers, bracing and removal, making a cost per pit of about $44. This wood was good for only 2 or 3 drivings, an average of 2½.

Two hundred and fifty tons of steel piling similar to the above, of the 6-in. x 12- ft. section, weighing 11 lbs. per ft., were purchased. This quantity was sufficient for about 40 pits, and it has already been re-used over 14 times, and is yet in very good condition. The bracing consists of 2 sets of 6x8-in. rangers with one cross bar of the same dimensions, but it has been found that lighter bracing can be used. This piling was driven by hand, with wooden mauls for about one-half the distance, and with iron sledges for the remainder, a special cap being employed. It was pulled by hand, also, with a wooden beam for a lever.

The average cost of 40 pits sheathed with steel piling has been $14.63 for driving and $4.84 for pulling, or about 2¾ cts. and 1 ct. per sq. ft., respectively. The steel piling cost $222 per pit, or 43 cts. per sq. ft. For the 14 times it has been re-used, this makes a total cost as follows:

Steel material	$222.00
Driving 14 times	205.00
Pulling 14 times	68.00
Total for 14 pits	$495.00
Average cost of 1 pit	35.30

This shows a saving over wood of about $9 per pit, or 20 per cent, and the steel material is still available for future use.

The above matter has been compiled from an article by Mr. F. T. Lewellyn in *Engineering Record.*

The table on following page has been abstracted from the Carnegie Steel Co.'s booklet, "Steel Sheet Piling."

TABLE 128.—COST OF DRIVING STEEL SHEET PILING.

Note.—First 34 items U. S. Steel sheet piling. Next 7 items Friestedt interlocking channel bar piling. Next 3 items symmetrical interlock channel bar piling.

	Kinds.					No. driven per day.					
	Width, ins.	Weight, lbs.	Net tons.	Length, ft.	Penetration, ft.	Max.	Min.	Type of hammer.	Cost, cents per ft.	Material.	Remarks.
Mt. Carmel, Ill.	12	35	366	28	22	32	20	Drop	2.75	Sand, fine gravel.	
Port Elizabeth, S. A.	12	35	96	20	15	9	4	Drop	10.60	Stiff clay silt.	Slow hammer, handling included.
Glen, Ohio	12	35	67	16	10	35	15	Drop	6.00	Riprap, sand and gravel.	
Hartnett, Pa.	12	35	38	22	22	16	11	Drop	3.00	Filled earth, clay, sand.	
Des Moines, Ia.	12	35	85	26	16	40	35	Drop	5.00	Clay, gravel.	
Winnipeg, Man.	12	35	154	35	30	30	13	Drop	4.50	Clay hardpan.	
St. Cloud, Minn.	12	35	61	18	18	35	20	Drop	12.00		Labor, fuel, oil, etc.
Decatur River, Ill.	12	35	72	14	11	..	..	Drop	11.90	Sand, gravel.	Labor and equipment.
Louisville, Ky.	12	35	113	30	21	100	80	Drop	5.00	Silt, sand.	
Williamsport, Ind.	12	35	28	12	12	..	..	Drop	6.64	Sand, coarse gravel.	Labor and equipment.
Butler, Pa.	12	35	312	20	20	30	3	Steam	12.50	Sand, blue clay.	Price paid contractor.
Bloomer, Wis.	12	35	18	10	10	..	..	Maul	29.00	Quicksand.	Labor and equipment.
Albion, Neb.	12	35	35	26	10	14	6	Drop	10.00	Clean sand.	
Rothschilds, Wis.	12	35	505	30	28	40	35	Steam	3.50	Coarse sand, gravel.	
Newark, N. J.	12	35	140	25	23	20	..	Steam	11.50	Gravel, sand, hardpan.	
Neligh, Neb.	12	35	35	20	12	26	2	Drop	8.00	Sand.	
Hatfield, Wis.	12	35	150	35	31	15	..	Drop	21.00	Sand, clay, gravel.	
Otisco Lake, N. Y.	12	35	46	20	18	15	3	Drop	17.00		Much time lost, labor and equipment.
Minneapolis, Minn.	12	35	15	14	14	16	13	Steam	7.00	Sand, gravel, boulders.	
Milwaukee, Wis.	12	35	21	30	30	30	12	Drop	7.90	Clay, quicksand, gravel.	
Minnehaha, Minn.	12	35	182	35	29	34	13	Steam	7.40	Sand, gravel.	Labor and equipment.
Evansville, Ind.	12	35	105	20	19	86	10	Drop	0.63	Clay loam, sand.	
St. Louis, Mo.	12	35	15	10	10	..	..	Drop	4.00	Clay, quicksand.	
Barrow in Furness, Eng.	12	35	92	25	24	6	4	Drop	63.00	Marl.	Driven under water—divers.
Pittsburgh, Pa.	12	35	134	24	5	105	20	Drop	5.00	River mud, silt.	
Monterey, Mex.	12	40	130	24	20	28	5	Drop	9.00		
Evansville, Ind.	12	40	81	20	20	31	26	Drop	5.00	Close packed sand.	
Evansville, Ind.	12	40	81	20	17	31	26	Drop	10.00	Close packed sand	
Kilbourne, Wis.	12	40	176	34	30	20	3	Drop	10.00	Sand.	Driving, handling.
Fargo, N. D.	12	40	58	20	20	20	8	Drop	10.00	Sand, gravel.	Inexperienced crew.
Pittsburgh, Pa.	12	40	400	Sp.	50	33	12	Drop	14.80	Heavy clay.	Price paid contractor.
Brownsville, Pa.	12	40	335	25	20	60	8	Drop	3.90	Sand, clay, hardpan.	
Brownsville, Pa.	12	40	77	45	44	20	15	Drop	15.00	Sand, clay, hardpan.	Labor, equipment, etc.
Waukegan, Ill.	12	40	17	14	10	10	6	Drop	11.40	Sand, gravel, hard clay.	Handling cost, 13.6 cts.
Chicago, Ill.	15	54	810	65	9	..	..	Steam	10.00	Silt clay.	
Omaha, Neb.	15	44	85	30	14	30	10	Drop	6.50	Slag, quicksand.	
Inglis, Fla.	12	29	70	20	16	26	2	Drop	16.00	6 ft. into sandstone.	Price paid contractor.
West Point, Ky.	12	33	120	37	15	25	1	Drop	30.00	Mud, clay, gravel.	Difficult job.
Berrien Springs, Mich.	15	41	900	30	30	35	14	Steam	11.00	Mud, sand, clay.	Labor handling.
Rock Island, Ill.	15	41	21	17	16	15	12	Drop	14.50	Gravel, hardpan.	
New York, N. Y.	15	38	75	15	15	..	..	Drop	20.00	Earth, sand, gravel.	Price paid contractor.
Preston Park, Pa.	15	39	142	40	34	22	8	Drop	5.33	Decayed vegetation, clay.	
Evansville, Ind.	10	28	26	14	12	35	25	Drop	7.50	Clay, shale, cobbles.	
Tomahawk, Wis.	15	45	148	22	16	16	2	Drop	20.00	Very hard driving up to 290 blows per ft.	

JACKSON'S INTERLOCKING STEEL SHEETING.

Costs about 1.5 cts. per lb. "base."

STYLE No. 1.

Composed of 15-inch, 33-lb. Channels, and 15-inch, 42-lb. I-Beams.	Weight, 49 lbs. per sq. ft.
or	
12-inch, 20½-lb. Channels, and 12-inch, 31½-lb. I-Beams.	Weight, 40 lbs. per sq. ft.

STYLE No. 2.

Composed of 5-inch, 6½-lb. Channels, and 9-inch, 21-lb. I-Beams.	Weight, 33 lbs. per sq. ft.

Furnished with or without wood filling.

STYLE No. 3.

Composed of standard 12-inch, 31½-lb. I-Beams, with patented Interlocking Clips,	Weight, 34 lbs. per sq. ft.
or	
9-inch, 21-lb. I-Beams, with patented Interlocking Clips.	Weight, 30 lbs. per sq. ft.

This material is classified under freight schedules as "Structural Steel." Can be furnished in any length.

CONCRETE PILES.

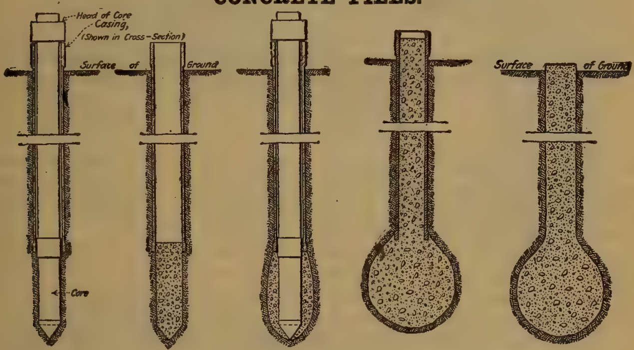


Fig. 200. Fig. 201. Fig. 202. Fig. 203. Fig. 204.

Fig. 200. A core and cylindrical casing are first driven to the required depth.
Fig. 201. The core is now removed and a charge of concrete dumped to the bottom of the casing.
Fig. 202. The core is now used as a rammer, to compress this concrete into the surrounding soil. The process is repeated until the base is about 3 feet in diameter.
Fig. 203. The enlarged base being completed the casing is filled to the top with wet concrete.
Fig. 204. The final step is to withdraw the cylindrical casing from the ground. The completed Pedestal Pile, consisting of a monolithic concrete column 17 inches in diameter surmounting a broad base 3 feet in diameter, is thus left in the ground.

Concrete piles may be divided into two classes, those molded and hardened before driving and those molded in place. There are several patented methods of driving and molding piles in place, some presenting advantages over others under different conditions to be met in the work and soil. The Simplex pile employs a cylinder to which is fitted a cast iron or steel point; when the pile has been driven to the required depth the cylinder is filled with concrete and is then pulled out, leaving the point at the bottom and the wet concrete, settling, completely fills the hole. The Pedestal pile is constructed by driving a cylinder and

Fig. 205. Two views of the foot of an experimental Pedestal Pile. The large irregular projection is a stone which was cemented into the foot.

core together. When the required depth is reached the core is withdrawn, some concrete is poured in and the core is then used as a tamper to compress the concrete below the cylinder into the ground to form an enlarged bearing foot or "pedestal."

It is evident that in soft, water bearing ground or in ground below water the above methods cannot be used or, if used in very soft ground, there cannot be any certainty that a perfect pile has been made, and the result at best must be doubtful. Such conditions are met satisfactorily and well by the Raymond method. A tapering shell and core are driven in the ground together. The shell is left in the ground and filled with concrete. In any of the above methods reinforcing steel may be introduced as required. These piles are all controlled by the patentees or those licensed by them, who take contracts for doing the work themselves. Mr. Gillette gives costs for the Simplex, 10 cents per lineal foot, which should also be about the cost of the pedestal pile.

The John Simmons Co. are supplying sectional casings in lengths of 4 ft. to 20 ft. The sections are fitted together as the driving proceeds by means of an interior sleeve; the pile may be driven with a cast point, or if without a point the dirt or sand

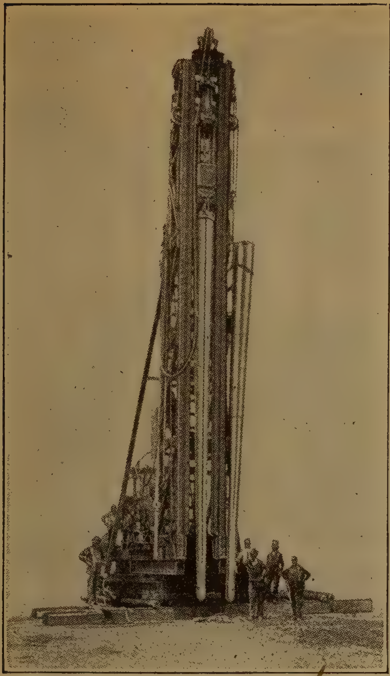


Fig. 206. Raymond Pile Core and Shell. The Shell Shown to the Right of Core Appears as It Would Be When in Position in the Soil.

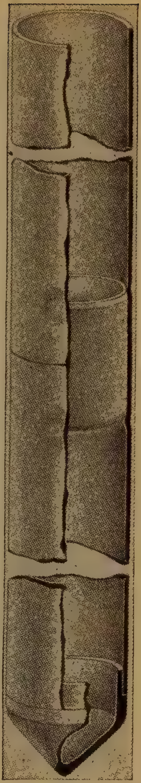


Fig. 207.

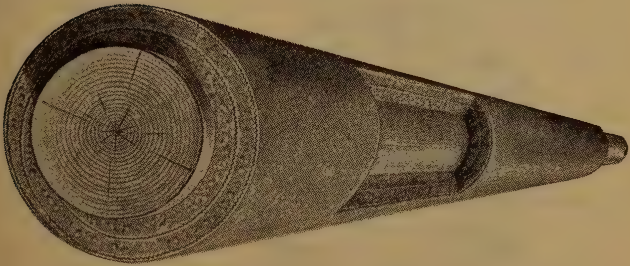


Fig. 208. Ripley Combination Wood and Concrete Pile.

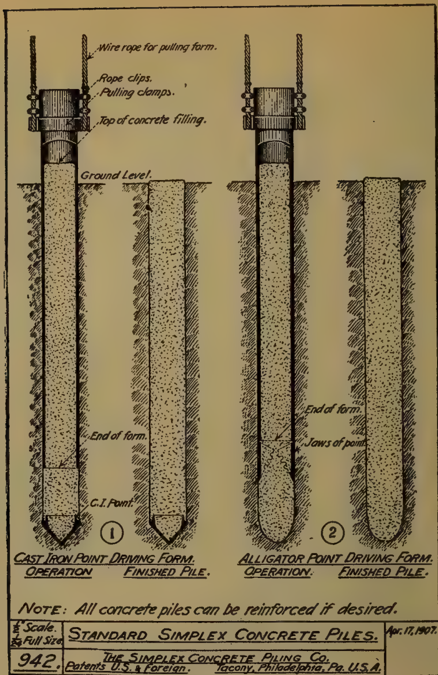


Fig. 209.

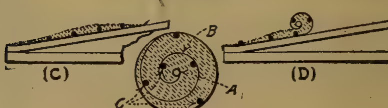


Fig. 210.

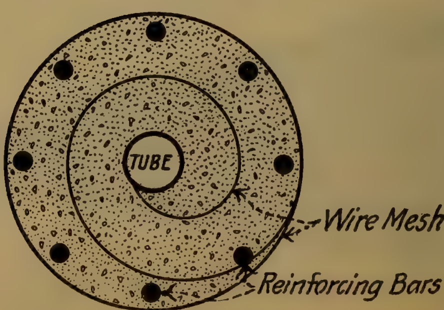


Fig. 211. End Cross Section for All Piles.

may be jetted out, the concrete in either case being poured in when the pile has reached the required depth. The particular advantage of this pile is that it can be used where the head room is limited. The cost of casing ranges from 83 cts. a foot to $2.75, depending upon the sizes (9-in. to 12-in.) and the length of the pieces.

Cast piles may be made in any section, circular, square, triangular, or corrugated. They are reinforced with bars or mesh or with bars and mesh, or with bars and hoops or even with built-up sections, as I-beams; in short, piles are reinforced just as columns. They are driven in the same way as are wooden piles.

Piles are cast in horizontal molds like beams, or in vertical

Fig. 212. Chenoweth Machine for Manufacturing Reinforced Concrete Piles 60 Feet Long, 14 to 16 inches in Diameter.

molds like columns. They are allowed to set hard before forms are removed and to harden thoroughly for 30 days before being driven. Often an iron pipe is molded in the pile at its center throughout its length for use of a water jet to help in the driving.

Mr. Gillette gives costs of making and driving 48 piles, 30 ft. 6 ins. long, 14 in. x 14 in. at butt, and 9 in. x 9 in. at tip, as $1.63 per lin. ft., admittedly a high cost. The cost per lin. ft. of pile for the Atlantic City, N. J., board walk is given as $1.41. This, too, is a high cost, as the piles were of more or less complicated construction. They were jetted down, no driving being done.

The Chenoweth pile is reinforced with rods and wire mesh, the rods are wired to the mesh, the concrete is then spread flat on the mesh, and all are rolled together on a machine built for the purpose. Piles up to 61 ft. in length can be made on this machine. They are driven with a regular pile driving machine,

preferably, as is the case with all concrete piles, with a machine having a steam hammer. Mr. Gillette gives the cost of this pile as $1.50 per lin. ft. in place.

Another rolled pile is the Ripley Combination pile, in which concrete reinforced with wire mesh is rolled around a wooden

Fig. 213. Cast Iron Point Driving Form Ready to Start Driving. Point in Position and Form Being Lowered.

pile. The concrete in this case is useful to strengthen the pile and, particularly, to protect it from the action of the teredo or marine borer, for in docks having a concrete superstructure of girders and beams, the joint of the girder and wood and concrete pile would be a difficulty, tending rather to the making of a weak joint at a critical point of the structure.

PIPE

APPROXIMATE WEIGHTS, DIMENSIONS, ETC.

Standard Sewer Pipe.

Calibre, Inches.	Thickness, Inches.	Weight per Foot, Pounds.	Depth of Sockets, Inches.	Annular Space, Inches.	Av.* Price per Foot.
3	½	7	1½	¼	$0.075
4	½	9	1⅝	⅜	.075
5	⅝	12	1¾	⅜	.12
6	⅝	15	1⅞	⅜	.12
8	¾	23	2	⅜	.165
9	13/16	28	2	⅜	.24
10	⅞	35	2⅛	⅜	.24
12	1	45	2¼	½	.30
15	1⅛	60	2½	½	.405
18	1¼	85	2¾	½	.57
20	1⅜	100	3	½	.675
21	1½	120	3	½	.90
22	1½	130	3	½	.90
24	1⅝	150	3¼	½	.975
27	2	224	4	¾	1.71
30	2⅛	250	4	¾	2.09
33	2¼	310	5	1¼	2.69
36	2½	350	5	1¼	3.01

Double Strength Pipe.

Calibre, Inches.	Thickness, Inches.	Weight per Foot, Pounds.	Depth of Sockets, Inches.	Annular Space, Inches.	Av.* Price per Foot.
15	1¼	75	2½	½	$0.473
18	1½	105	2¾	½	.685
20	1⅔	130	3	½	.833
21	1¾	148	3	½	1.11
22	1 5/6	160	3	½	1.11
24	2	185	3¼	½	1.20
27	2¼	260	4	¾	2.07
30	2½	310	4	¾	2.53
33	2⅝	340	5	1¼	3.19
36	2¾	400	5	1¼	3.57

APPROXIMATE WEIGHTS, DIMENSIONS, ETC.

Deep and Wide Sockets, Standard.

Calibre, Inches.	Thickness, Inches.	Weight per Foot, Pounds.	Depth of Sockets, Inches.	Annular Space, Inches.	Av.* Price per Foot.
4	½	10	2	½	$0.0775
5	⅝	14	2½	⅝	.124
6	⅝	16	2½	⅝	.124
8	¾	25	2¾	⅝	.1705
10	⅞	36	2¾	⅝	.248
12	1	46	3	⅝	.31
15	1⅛	65	3	⅝	.419
18	1¼	86	3¼	⅝	.589
20	1⅜	107	3½	⅝	.697
21	1½	130	3⅝	⅝	.93
22	1⅝	145	3¾	⅝	.93
24	1⅝	150	4	⅝	1.007

*There is a wide variation in prices of this product. The prices given on this and following page are for standard length pipe in carload lots, delivered at New York, and are the average prices for 1913.

For pipe in 3 ft. lengths, with standard sockets, prices are approximately the same as the corresponding prices for pipe with deep and wide sockets.

For 3 ft. lengths with deep and wide sockets the prices are approximately equal to the given prices for deep and wide socket pipe plus the difference between deep and wide socket and standard socket pipe.

APPROXIMATE WEIGHTS, DIMENSIONS, ETC.

Deep and Wide Sockets, Double Strength.

Calibre, Inches.	Thickness, Inches.	Weight per Foot, Pounds.	Depth of Sockets, Inches.	Annular Space, Inches.	Av.* Price per Foot.
15	1¼	76	3	⅝	$0.486
18	1½	107	3¼	⅝	.703
20	1⅔	135	3½	⅝	.855
21	1¾	148	3⅝	⅝	1.14
22	1 5/6	165	3¾	⅝	1.14
24	2	190	4	⅝	1.235

DRAIN TILE.

QUANTITY OF PIPE IN MINIMUM CARLOAD OF 24,000 LBS.

No. Inches.	Standard, Feet.	Double Strength.
3	3,500	...
4	3,000	...
5	2,000	...
6	1,700	...
8	1,100	...
9	1,000	...
10	700	320
12	600	240
15	450	192
18	308	160
20	234	136
24	160	100
27	110	90
30	100	75
36	75	65

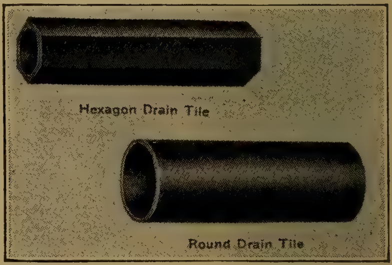
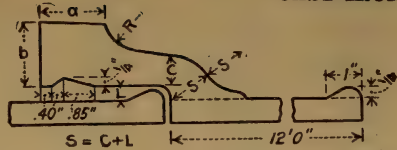


Fig. 214.

DRAIN TILE HARD BURNED AND VITRIFIED.

Size, Inches.	List Price: Per 1,000 Feet.	List Price: Ys, Ts, Ells and Curves, Each.	Approximate Weight per 1,000 Feet.
2	$14.00	$.07	3,000
2½	15.00	.075	3,500
3	18.00	.09	4,000
4	24.00	.12	7,000
5	36.00	.18	10,000
6	45.00	.225	13,000

CAST IRON WATER PIPE.



X = ¾" on 3" to 6" inclusive.
V = $\frac{3}{16}$" on 3" to 6" inclusive.
X = 1" on 8" to 84" inclusive.
V = ¼" on 8" to 84" inclusive.

Fig. 215.

TABLE 129.—STANDARD DIMENSIONS OF PIPE.

Classes A, B, C, D.

Nominal Diam. Inches.	Classes.	Actual Outside Diameter, Inches.	Diam. of Sockets. Pipe, Inches.	Diam. of Sockets. Special Castings, Inches.	Depth of Sockets. Pipe, Inches.	Depth of Sockets. Special Castings, Inches.	a.	b.	c.
4	A	4.80	5.60	5.70	3.50	4.00	1.5	1.30	.65
4	B–C–D	5.00	5.80	5.70	3.50	4.00	1.5	1.30	.65
6	A	6.90	7.70	7.80	3.50	4.00	1.5	1.40	.70
6	B–C–D	7.10	7.90	7.80	3.50	4.00	1.5	1.40	.70
8	A–B	9.05	9.85	10.00	4.00	4.00	1.5	1.50	.75
8	C–D	9.30	10.10	10.00	4.00	4.00	1.5	1.50	.75
10	A–B	11.10	11.90	12.10	4.00	4.00	1.5	1.50	.75
10	C–D	11.40	12.20	12.10	4.00	4.00	1.5	1.60	.80
12	A–B	13.20	14.00	14.20	4.00	4.00	1.5	1.60	.80
12	C–D	13.50	14.30	14.20	4.00	4.00	1.5	1.70	.85
14	A–B	15.30	16.10	16.10	4.00	4.00	1.5	1.70	.85
14	C–D	15.65	16.45	16.45	4.00	4.00	1.5	1.80	.90
16	A–B	17.40	18.40	18.40	4.00	4.00	1.75	1.80	.90
16	C–D	17.80	18.80	18.80	4.00	4.00	1.75	1.90	1.00
18	A–B	19.50	20.50	20.50	4.00	4.00	1.75	1.90	.95
18	C–D	19.92	20.92	20.92	4.00	4.00	1.75	2.10	1.05
20	A–B	21.60	22.60	22.60	4.00	4.00	1.75	2.00	1.00
20	C–D	22.06	23.06	23.06	4.00	4.00	1.75	2.30	1.15
24	A–B	25.80	26.80	26.80	4.00	4.00	2.00	2.10	1.05
24	C–D	26.32	27.32	27.32	4.00	4.00	2.00	2.50	1.25

TABLE 129.—STANDARD DIMENSIONS OF PIPE—Continued.

Nominal Diam. Inches.	Classes.	Diam. of Sockets: Actual Outside Diameter, Inches.	Diam. of Sockets: Pipe, Inches.	Diam. of Sockets: Special Castings, Inches.	Depth of Sockets: Pipe, Inches.	Depth of Sockets: Special Castings, Inches.	a.	b.	c.
30	A	31.74	32.74	32.74	4.50	4.50	2.00	2.30	1.15
30	B	32.00	33.00	33.00	4.50	4.50	2.00	2.30	1.15
30	C	32.40	33.40	33.40	4.50	4.50	2.00	2.60	1.32
30	D	32.74	33.74	33.74	4.50	4.50	2.00	3.00	1.50
36	A	37.96	38.96	38.96	4.50	4.50	2.00	2.50	1.25
36	B	38.30	39.30	39.30	4.50	4.50	2.00	2.80	1.40
36	C	38.70	39.70	39.70	4.50	4.50	2.00	3.10	1.60
36	D	39.16	40.16	40.16	4.50	4.50	2.00	3.40	1.80
42	A	44.20	45.20	45.20	5.00	5.00	2.00	2.80	1.40
42	B	44.50	45.50	45.50	5.00	5.00	2.00	3.00	1.50
42	C	45.10	46.10	46.10	5.00	5.00	2.00	3.40	1.75
42	D	45.58	46.58	46.58	5.00	5.00	2.00	3.80	1.95
48	A	50.50	51.50	51.50	5.00	5.00	2.00	3.00	1.50
48	B	50.80	51.80	51.80	5.00	5.00	2.00	3.30	1.65
48	C	51.40	52.40	52.40	5.00	5.00	2.00	3.80	1.95
48	D	51.98	52.98	52.98	5.00	5.00	2.00	4.20	2.20
54	A	56.66	57.66	57.66	5.50	5.50	2.25	3.20	1.60
54	B	57.10	58.10	58.10	5.50	5.50	2.25	3.60	1.80
54	C	57 80	58.80	58.80	5.50	5.50	2.25	4.00	2.15
54	D	58.40	59.40	59.40	5.50	5.50	2.25	4.40	2.45
60	A	62.80	63.80	63.80	5.50	5.50	2.25	3.40	1.70
60	B	63.40	64.40	64.40	5.50	5.50	2.25	3.70	1.90
60	C	64.20	65.20	65.20	5.50	5.50	2.25	4.20	2.25
60	D	64.82	65.82	65.82	5.50	5.50	2.25	4.70	2.60
72	A	75.34	76.34	76.34	5.50	5.50	2.25	3.80	1.87
72	B	76.00	77.00	77.00	5.50	5.50	2.25	4.20	2.20
72	C	76.88	77.88	77.88	5.50	5.50	2.25	4.60	2.64
84	A	87.54	88.54	88.54	5.50	5.50	2.50	4.10	2.10
84	B	88.54	89.54	89.54	5.50	5.50	2.50	4.50	2.60

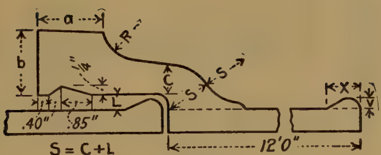


Fig. 216.

TABLE 130.—STANDARD DIMENSIONS OF PIPE.

High Pressure Service.
Classes E, F, G, H.

Nominal Diameter, Inches,	Classes.	Actual Outside Diameter, Inches.	Diam. of Sockets.	Depth of Sockets.	a	b	c	R	Nominal Diameter, Inches.
		Pipes and Specials.							
6	E–F	7.22	8.02	4.00	1.50	1.75	.75	1.10	6
6	G–H	7.38	8.18	4.00	1.50	1.85	.85	1.10	6
8	E–F	9.42	10.22	4.00	1.50	1.85	.85	1.10	8
8	G–H	9.60	10.40	4.00	1.50	1.95	.95	1.10	8
10	E–F	11.60	12.40	4.50	1.75	1.95	.95	1.10	10
10	G–H	11.84	12.64	4.50	1.75	2.05	1.05	1.10	10
12	E–F	13.78	14.58	4.50	1.75	2.05	1.05	1.10	12
12	G–H	14.08	14.88	4.50	1.75	2.20	1.20	1.10	12
14	E–F	15.98	16.78	4.50	2.00	2.15	1.15	1.10	14
14	G–H	16.32	17.12	4.50	2.00	2.35	1.35	1.10	14
16	E–F	18.16	18.96	4.50	2.00	2.30	1.25	1.15	16
16	G–H	18.54	19.34	4.50	2.00	2.55	1.45	1.15	16
18	E–F	20.34	21.14	4.50	2.25	2.45	1.40	1.15	18
18	G–H	20.78	21.58	4.50	2.25	2.75	1.65	1.15	18
20	E–F	22.54	23.34	4.50	2.25	2.55	1.50	1.15	20
20	G–H	23.02	23.82	4.50	2.25	2.85	1.75	1.20	20
24	E–F	26.90	27.90	5.00	2.25	2.85	1.70	1.20	24
30	E	33.10	34.10	5.00	2.25	3.25	1.80	1.50	30
30	F	33.46	34.46	5.00	2.25	3.50	2.00	1.55	30
36	E	39.60	40.60	5.00	2.25	3.70	2.05	1.70	36
36	F	40.04	41.04	5.00	2.25	4.00	2.30	1.80	36

TABLE 131.—STANDARD THICKNESS AND WEIGHTS OF CAST IRON PIPE.

Classes A, B, C, D.

Nominal Inside Diam. (Ins.)	CLASS A 100-Feet Head 43 Lbs. Pressure			CLASS B 200-Feet Head 86 Lbs. Pressure			CLASS C 300-Feet Head 130 Lbs. Pressure			CLASS D 400-Feet Head 173 Lbs. Pressure			Nominal Inside Diam. (Ins.)
	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	
4	.42	20.0	240	.45	21.7	260	.48	23.3	280	.52	25.0	300	4
6	.44	30.8	370	.48	33.3	400	.51	35.8	430	.55	38.3	460	6
8	.46	42.9	515	.51	47.5	570	.56	52.1	625	.60	55.8	670	8
10	.50	57.1	685	.57	63.8	765	.62	70.8	850	.68	76.7	920	10
12	.54	72.5	870	.62	82.1	985	.68	91.7	1100	.75	100.0	1200	12
14	.57	89.6	1075	.66	102.5	1230	.74	116.7	1400	.82	129.2	1550	14
16	.60	108.3	1300	.70	125.0	1500	.80	143.8	1725	.89	158.3	1900	16
18	.64	129.2	1550	.75	150.0	1800	.87	175.0	2100	.96	191.7	2300	18
20	.67	150.0	1800	.80	175.0	2100	.92	208.3	2500	1.03	229.2	2750	20
24	.76	204.2	2450	.89	233.3	2800	1.04	279.2	3350	1.16	306.7	3680	24
30	.88	291.7	3500	1.03	333.3	4000	1.20	400.0	4800	1.37	450.0	5400	30
36	.99	391.7	4700	1.15	454.2	5450	1.36	545.8	6550	1.58	625.0	7500	36
42	1.10	512.5	6150	1.28	591.7	7100	1.54	716.7	8600	1.78	825.0	9900	42
48	1.26	666.7	8000	1.42	750.0	9000	1.71	908.3	10900	1.96	1050.0	12600	48
54	1.35	800.0	9600	1.55	933.3	11200	1.90	1141.7	13700	2.23	1341.7	16100	54
60	1.39	916.7	11000	1.67	1104.2	13250	2.00	1341.7	16100	2.38	1583.3	19000	60
72	1.62	1283.4	15400	1.95	1545.8	18550	2.39	1904.2	22850	...	.....	.....	72
84	1.72	1633.4	19600	2.22	2104.2	25250	...	.....	.....	...	.....	.....	84

The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

TABLE 132.—STANDARD THICKNESS AND WEIGHTS OF CAST IRON PIPE.

For Fire Lines and Other High Pressure Service. Classes E, F, G, H.

Nominal Inside Diam. (Ins.)	CLASS E 500-Feet Head 217 Lbs. Pressure			CLASS F 600-Feet Head 260 Lbs. Pressure			CLASS G 700-Feet Head 340 Lbs. Pressure			CLASS H 800-Feet Head 347 Lbs. Pressure			Nominal Inside Diam. (Ins.)
	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	Thickness Ins.	Weight per Foot	Weight per Length	
6	.58	41.7	500	.61	43.3	520	.65	47.1	565	.69	49.6	595	6
8	.66	61.7	740	.71	65.7	790	.75	70.8	850	.80	75.0	900	8
10	.74	86.3	1035	.80	92.1	1105	.86	100.9	1210	.92	106.7	1280	10
12	.82	113.8	1365	.89	122.1	1465	.97	135.4	1625	1.04	143.8	1725	12
14	.90	145.0	1740	.99	157.5	1890	1.07	174.2	2090	1.16	186.7	2240	14
16	.98	179.6	2155	1.08	195.4	2345	1.18	219.2	2620	1.27	232.5	2790	16
18	1.07	220.4	2645	1.17	238.4	2860	1.28	267.1	3205	1.39	286.7	3440	18
20	1.15	263.0	3155	1.27	286.3	3435	1.39	320.8	3850	1.51	344.6	4135	20
24	1.31	359.6	4315	1.45	392.9	4715	...	....	....	...	....	....	24
30	1.55	521.7	6260	1.73	585.4	7025	...	....	....	...	....	....	30
36	1.80	725.0	8700	2.02	820.0	9840	...	....	....	...	....	....	36

The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

For High Pressure Pipe from 6 inches to 24 inches inclusive, one class of special castings shall be furnished for Classes E and F pipe, and one class of special castings for Classes G and H pipe. For 30-inch and 36-inch pipe, one class of special castings shall be furnished for each class of pipe.

TABLE 133.—WROUGHT IRON PIPE FOR STEAM, GAS OR WATER.

Table of Standard Dimensions.

Nominal Inside Diameter	Actual Inside Diam. (Ins.)	Actual Outside Diam. (Ins.)	Internal Circumference (Ins.)	External Circumference (Ins.)	Length of Pipe per Sq. Ft. of Inside Surface (Ft.)	Length of Pipe per Sq. Ft. of Outside Surface (Ft.)	Internal Area (Sq. Ins.)	External Area (Sq. Ins.)	Length of Pipe Containing 1 Cu. Ft. (Ft.)	Nominal Weight per Ft. (Lbs.)	No. of Threads per In. of Screw	Contents in Gallons per Foot
⅛	0.270	0.405	0.848	1.272	14.15	9.44	0.0572	0.129	2500.0	0.243	27	.0029
¼	0.364	0.54	1.144	1.696	10.50	7.075	0.1041	0.229	1385.0	0.422	18	.0054
⅜	0.494	0.675	1.552	2.121	7.732	5.657	0.1916	0.358	751.5	0.561	18	.0099
½	0.623	0.84	1.957	2.639	6.13	4.502	0.3048	0.554	472.4	0.845	14	.0158
¾	0.824	1.05	2.589	3.299	4.635	3.637	0.5333	0.866	270.0	1.126	14	.0277
1	1.048	1.315	3.292	4.134	3.645	2.903	0.8627	1.357	166.9	1.67	11½	.0447
1¼	1.380	1.66	4.335	5.215	2.768	2.301	1.496	2.164	96.25	2.258	11½	.0777
1½	1.611	1.9	5.061	5.969	2.371	2.01	2.038	2.835	70.65	2.694	11½	.1058
2	2.067	2.375	6.434	7.461	1.848	1.611	3.355	4.430	42.91	3.667	11½	.1743
2½	2.468	2.875	7.754	9.032	1.547	1.328	4.783	6.491	30.11	5.773	8	.2483
3	3.067	3.5	9.636	10.996	1.245	1.091	7.383	9.621	19.49	7.547	8	.3835
3½	3.548	4.0	11.146	12.566	1.077	0.955	9.887	12.566	14.56	9.055	8	.5136
4	4.026	4.5	12.648	14.137	0.949	0.849	12.730	15.904	11.31	10.66	8	.6613
4½	4.508	5.0	14.162	15.708	0.848	0.765	15.961	19.635	9.03	12.34	8	.829
5	5.045	5.563	15.849	17.475	0.757	0.687	19.990	24.299	7.20	14.564	8	1.038
6	6.065	6.625	19.054	20.813	0.63	0.577	28.899	34.471	4.98	18.767	8	1.500
7	7.023	7.625	22.063	23.954	0.544	0.505	38.737	45.663	3.72	23.27	8	2.012
8	7.982	8.625	25.076	27.096	0.478	0.444	50.027	58.426	2.88	28.18	3	2.599
9	8.937	9.625	28.076	30.238	0.425	0.394	62.730	72.760	2.29	33.077	8	3.259
10	10.019	10.75	31.475	33.772	0.381	0.355	78.838	90.762	1.80	40.641	8	4.095
11	11.0	11.75	34.55	36.91	0.347	0.32	95.03	108.43	1.50	45.0	8	4.937
12	12.0	12.75	37.70	40.05	0.318	0.30	113.0	127.67	1.27	48.98	8	5.87

TABLE 134.—EQUATION OF PIPES.

Standard Steam and Gas Pipes.

Dia. In.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12
½		2.27	4.88	15.8	31.7	52.9	96.9	205	377	620	918	1,292	1,767	2,488	3,014	3,786
¾	2.60		2.05	6.97	14.0	23.3	42.5	90.4	166	273	405	569	779	1,096	1,328	1,668
1	7.55	2.90		3.45	6.82	11.4	20.9	44.1	81.1	133	198	278	380	536	649	815
1½	24.2	9.30	3.20		1.26	3.84	6.13	13.0	23.8	39.2	58.1	81.7	112	157	190	239
2	54.8	21.0	7.25	2.26		1.67	3.06	6.47	11.9	19.6	29.0	40.8	55.8	78.5	95.1	119
2½	102	39.4	13.6	4.23	1.87		1.83	3.87	7.12	11.7	17.4	24.4	33.4	47.0	56.9	71.5
3	170	65.4	22.6	7.03	3.11	1.66		2.12	3.89	6.39	9.48	13.3	20.9	23.7	31.2	39.1
4	376	144	49.8	15.5	6.87	3.67	2.21		1.84	3.02	4.48	6.30	8.61	12.1	14.7	18.5
5	686	263	90.9	28.3	12.5	6.70	4.03	1.83		1.65	2.44	3.43	4.69	6.60	8.0	10.0
6	1,116	429	148	46.0	20.4	10.9	6.56	2.97	1.63		1.48	2.09	2.85	4.02	4.86	6.11
7	1,707	656	226	70.5	31.2	16.6	10.0	4.54	2.49	1.51		1.41	1.93	2.71	3.28	4.12
8	2,435	936	322	101	44.5	23.8	14.3	6.48	3.54	2.18	1.43		1.35	1.93	2.33	2.92
9	3,335	1,281	440	137	60.8	32.5	19.5	8.85	4.85	2.98	1.95	1.37		1.41	1.71	2.14
10	4,393	1,688	582	181	80.4	42.9	25.8	11.7	6.40	3.93	2.57	1.80	1.32		1.21	1.52
11	5,642	2,168	747	233	103	55.1	33.1	15.0	8.22	5.05	3.31	2.32	1.70	1.28		1.26
12	7,087	2,723	938	293	129	69.2	41.6	18.8	10.3	6.34	4.15	2.91	2.13	1.61	1.26	

This table gives the number of pipes of one size required to equal in delivery other larger pipes of same length and under same conditions. The upper portion above the diagonal line pertains to "Standard" steam and gas pipes, while the lower portion is for pipes of the actual internal diameter given. The figure given in the table opposite the intersection of any two sizes is the number of the smaller sized pipes required to equal one of the larger. Thus, it requires 29 standard 2 inch pipes to equal one standard 7 inch pipe.

WOOD STAVE PIPE.

Key to Table of Dimensions and Prices Following.

A—Machine banded fir stave pipe, f. o. b. ships tackle, Portland or Seattle. Pipe packed and crated for export.

B—Pipe made of Oregon or Douglas fir, with 1½ in. shell. Lengths of pipe from 8 to 16 ft., with not more than 10% less than 10 ft. Inserted joint couplings made of the pipe (slip joint), one end of pipe being trimmed off for 3 ins., forming a tenon, the other end to be reamed to receive tenon. The wire gauge used to be W.-M. Standard. No. 4 being 0.225 and No. 2 being 0.263 inches in diameter. (B 1)—Wood sleeve coupling to be of same class of material as the pipe sections, and not less than 6 ins. in length. No sap wood allowed in couplings. Coup-

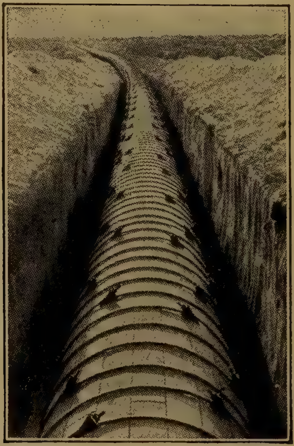


Fig. 217. Thirty-six Inch Continuous Wooden Stave Pipe for Irrigation System.

lings to be spirally wound with wire having a spacing not greater than one-half of spacing of wire on pipe. (B 2)—Individual band coupling to be made of staves and in same manner as wood sleeve coupling, except that individual bands of round mild steel of size designated shall be used for the banding. Each band to be headed and threaded and supplied with nut and washer, and a malleable cast iron or drop forged shoe to be used in cinching the bands. The wire used shall be galvanized and have a strength of not less than 60,000 pounds per square inch. The prices given are f. o. b. cars, Portland, Ore.

C—Fir pipe of 1½ in. staves, with 8 in. sleeve couplings, each with three individual ½ in. round mild steel bands.

D—Similar pipe to C, but with steel adjustable clamp couplings. Weight per foot approximately the same as C.

E—Similar to C but with ½ in. bands (spaced as shown in table) instead of spirally wound wire and shipped "knocked down." The weight of the lumber used would be about 2,200 lbs. per thousand board feet of lumber, and the weight of the bands per thousand lineal feet of pipe as shown in the table.

F—Pipe similar to E but with steel couplings similar to those used in D. The prices of pipe under C, D, E and F are given f. o. b. cars, dock, Tacoma.

G—Redwood pipe, machine banded, built in sections of random lengths of from 8 to 20 ft. Wire having tensile strength of 60,000 to 65,000 lbs. per sq. in. shall be spaced with a safety factor of 4. The staves shall be beveled and further provided with a small tongue and groove. Prices f. o. b., dock, San Francisco.

H—Continuous redwood stave pipe, shipped "knocked down." Lengths of staves to be from 10 to 20 ft. with about 30% of 12 ft. stock. Ends of staves to have metallic tongues made from 1½x⅛ in. band iron. Bands spaced with a factor of safety of 4, to be round mild steel with malleable iron shoes. The rods to have a tensile strength of 58,000 to 65,000 lbs. per sq. in. Prices f. o. b. dock, San Francisco, Cal.

TABLE 135.—DIMENSIONS AND PRICES OF WOOD STAVE PIPE.

Size	Head	A		B				C			D	E			F	G			H			
		Price per Ft. (Dollars)	Outside Diam., including Crating	Price per Ft. (Dollars)	Weight per Ft. (Lbs.)	Wire Gauge and Spacing	Outside Diam. of Pipe & Coupling	Price per Ft. (Dollars)	Weight per Ft. (Lbs.)	Wire Gauge and Spacing	Price per Ft. (Dollars)	Price per Ft. (Dollars)	Band Size and Space	Weight of Bands per M Ft. (Lbs.)	Price per Ft. (Dollars)	Price per Ft. (Dollars)	Weight per Ft. (Lbs.)	Cub. Contents (Cu. Ft.)	Price per Ft. (Dollars)	Weight of Staves per L. F. (Lbs.)	Weight of Bands per L. F. (Lbs.)	Cubic Contents Staves (Cu. Ft.)
12"	25'	0.44¾	17"	(B 1)		No. 4 Ga.				No. 2 Ga.			½"									
	50'	0.45¾		0.33½	17.8	3"	Pi. 15"															
	75'	0.46¾																				
	100'	0.48¼		0.37¾	19.1	1⅜"	Co. 17"	0.42	21	2½"	0.50	0.48½	10"	3,100	0.54½	0.55	16	1.5	0.72	14	4	0.8
14"	25'	0.52	19"	(B 2)		No. 4 Ga.				No. 2 Ga.			½"									
	50'	0.54¾		0.38½	20.7	3"	Pi. 17"															
	75'	0.56½																				
	100'	0.59½		0.46¾	23.0	1⅛"	Co. 19¼"	0.51	24	2⅛"	0.60	0.54	9¾"	3,670	0.62	0.67	20	2.0	0.81	15	5	0.9
16"	25'	0.61	21"	(B 2)		No. 2 Ga.				No. 2 Ga.			½"									
	50'	0.62½		0.48	24.4	3"	Pi. 19"															
	75'	0.64¼																				
	100'	0.68⅜		0.55¾	26.6	1⅞"	Co. 21¼"	0.59	27	1⅞"	0 69	0.60	8½"	5,000	0.70	0.78	24	2.5	0.90	16	6	1.0
18"	25'	0.69⅛	23"	(B 2)		No. 2 Ga.				No. 2 Ga.			½"									
	50'	0.71⅞		0.53½	27.2	3"	Pi. 21"															
	75'	0.74½																				
	100'	0.80⅜		0.65¾	30.8	1⅝"	Co. 23½"	0.69	31	1⅝"	0.80	0.68	7½"	6,250	0.80	0.92	28	3.0	1.03	18	8	1.2
20"	25'	0.76⅛	25"	(B 2)		No. 2 Ga.				No. 2 Ga.			½"									
	50'	0.79⅛		0.57½	29.9	3"	Pi. 23"															
	75'	0.82¾																				
	100'	0.90⅝		0.71¾	34.5	1½"	Co. 25½"	0.79	36	1½"	0.91	0.77	6¾"	7,420	0.91	1.06	32	3.5	1.16	20	10	1.4

The following table shows the approximate weight of machine banded pipe per lineal foot, banded for a head of 150 feet, and the number of feet of pipe that can be loaded on a car.

Size of Pipe (Inches)	Approx. Wt. per Ft. (Pounds)	Number of Feet in Carload
2	2½	9,000
3	3⅞	6,500
4	4¼	5,500
6	7½	3,500
8	9⅞	2,500
10	12½	1,500
12	14½	1,000
14	17	850
16	22	700
18	26	500
20	33	500
24	50	400

It is possible to use standard cast iron water pipe fittings on machine banded wooden stave pipe, but the size and weight of

Fig. 218. Twenty-four Inch Machine Banded Wooden Stave Pipe, Laid in Place, for Irrigation System.

such fittings make their use undesirable. Lighter cast iron fittings, built with smoother hubs, are especially designed for wooden pipe. The approximate weights of the smaller sizes are as follows:

Crosses		Tees		Ells		Bends	
Ins.	Lbs.	Ins.	Lbs.	Ins.	Lbs.	Ins.	Lbs.
2x2x2x2	33	2x2x2	25	2	14	4–45°	37
3x3x3x3	54	3x3x3	43	3	23	6–30°	48
4x4x3x3	72	3x3x2	57	4	44	6–45°	52
4x4x4x4	88	4x2x2	55	6	62	6–20°	46
6x6x4x4	121	4x3x3	58	8	82	8–20°	51
6x6x6x4	124	4x4x3	57			8–30°	62
6x6x6x6	133	4x4x4	71				
8x8x4x4	143	6x2x4	87				
8x4x8x4	164	6x4x4	91				
8x8x6x4	147	6x6x4	100				
8x8x6x6	166	6x6x6	113				
8x8x8x8	197	6x6x8	133				
		8x8x4	122				
		8x8x6	135				
		8x8x8	155				

When quotations on wooden stave pipe are requested, the following information should be furnished the manufacturer of pipe:

1—Purpose for which pipe is to be used.

2—Inside diameter and length of pipe required.

3—Head on pipe or pressure under which it is to be used. As the banding varies according to the head, it is necessary to state the lengths of pipe under different heads, or else furnish a profile of the line.

The prices given usually include the couplings.

PATENT CLAMP COLLAR.

A Clamp Collar is meritorious for various reasons and advantages: On dredge pipe, when pipe can be connected without the aid of block and fall, and other power devices, by simply abutting the ends of sections of pipe together and bringing the Clamp Col-

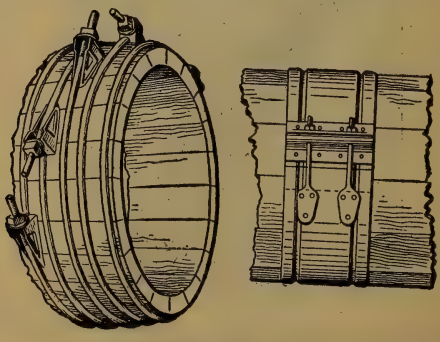


Fig. 219.

lar around the point and connecting up same by means of thread and nut, thereby making a perfectly tight joint; for its use in taking out a single section at any place in the line without disturbing any other portion of the line; in dredge and hydraulic

pipe that is worn thin on the under side, making it necessary to turn the pipe so as to get the strongest portion of the pipe underneath, where the greatest wear is encountered.

All that is necessary is to slacken the nuts on the Clamp Collar at the end of each section, thereby leaving it loose to be turned to such a position as is desired. A section of pipe frequently becomes worthless and in order to replace a section with a new one, other portions of the adjacent main do not have to be disturbed, as the section can be put in place, thereby repairing the break, disturbing only such portion as is useless.

PIPE COVERINGS

ASBESTOS.

These asbestos coverings are made for pipes ½ in. to 1½ in. inside diameter, ranging in ¼ in. sizes; for pipes 1½ in. to 5 in. inside diameter, ranging in ½ in. sizes; for pipes 5 in. to 10 in. inside diameter, ranging in 1 in. sizes; for pipes 10 in. to 20 in. inside diameter, ranging in 2 in. sizes, and for 24 in. and 30 in. pipes. All pipe coverings are supplied in sections of 3 ft. long, canvased and with bands.

Following is a price list, on which there is about 77 per cent discount:

PRICE LIST SECTIONAL PIPE COVERINGS AND FITTINGS.

Standard Thicknesses.

Inside Diam. of Pipe, Inches.	Price per Lineal Ft.	Elbows.	Tees.	Crosses.	Globe Valves.	Flange Covers.
½	$0.22	$0.30	$0.36	$0.48	$0.54	$0.50
¾	.24	.30	.36	.48	.54	.50
1	.27	.30	.36	.48	.54	.50
1¼	.30	.30	.36	.48	.54	.50
1½	.33	.30	.36	.48	.54	.50
2	.36	.36	.42	.54	.60	.60
2½	.40	.42	.48	.60	.78	.70
3	.45	.48	.54	.70	.96	.80
3½	.50	.54	.60	.80	1.20	.90
4	.60	.60	.75	.95	1.50	1.00
4½	.65	.72	.90	1.10	1.85	1.30
5	.70	.90	1.20	1.50	2.25	1.60
6	.80	1.30	1.60	2.00	2.80	1.90
7	1.00	1.80	2.20	2.80	3.60	2.20
8	1.10	2.40	3.00	3.60	4.40	2.50
9	1.20	3.00	3.80	4.40	5.30	2.90
10	1.30	3.60	4.60	5.20	6.20	3.30
*12	1.85					
14	2.10					
16	2.35					
18	2.60					
20	2.85					
24	3.30					
30	4.00					

All pipe coverings are supplied in sections three feet long canvased and with bands. For irregular flanges or fittings larger than 10 inches use our Magnesia Cement or Asbestos Cement Felting.

* All magnesia coverings above 12 inches furnished in segmental form; other coverings in sectional form in all sizes.
Subject to discount.

PRICE LIST SECTIONAL PIPE COVERINGS.

Extra Thicknesses.

Inside Diameter of Pipe, Inches.	1½-Inch Thick per Lineal Ft.	2-Inch Thick per Lineal Ft.	Dbl. Stand. Thick per Lineal Ft.	3-Inch Thick Broken Joint per Lineal Ft.
½	$0.46	$0.75	$0.65	$1.20
¾	.49	.80	.70	1.35
1	.52	.85	.75	1.40
1¼	.56	.90	.80	1.45
1½	.60	.95	.85	1.55
2	.64	1.00	.90	1.65
2½	.70	1.05	1.00	1.75
3	.76	1.15	1.10	1.90
3½	.82	1.25	1.20	2.05
4	.88	1.35	1.40	2.20
4½	.94	1.45	1.50	2.35
5	1.00	1.55	1.60	2.50
6	1.10	1.70	1.80	2.70
7	1.20	1.85	2.25	2.90
8	1.35	2.00	2.50	3.15
9	1.50	2.20	2.70	3.40
10	1.65	2.40	2.90	3.65
*12	1.85	2.70	4.10	4.10
14	2.10	3.00	4.60	4.60
16	2.35	3.30	5.10	5.10
18	2.60	3.60	5.60	5.60
20	2.85	4.00	6.00	6.00
24	3.30	4.50	7.00	7.00
30	4.00	5.50	8.40	8.40

* All magnesia coverings above 12 inches furnished in segmental form; other coverings in sectional form in all sizes.

Subject to discount.

PIPE LINE TOOLS

Lead furnace, pot, bar, grate and ladle on two wheels with handle and stand. Of heavy boiler plate with wrought iron wheels.

Diameter of Furnace, Inches.	Diameter of Pot, Inches.	Depth of Pot, Inches.	Capacity of Pot, Pounds.	Diameter of Ladle, Inches.	Price on Wheels f. o. b. N. Y.	Price on Legs.
18	13½	7½	200	8	$22.50	$16.75
24	15	11	450	9	26.25	22.50
30	18	14	850	10	33.75	28.00

Calking Tools. Calking hammers, 3 to 4 lbs., handled, $1.00.

Set of 5 calking tools, ¼ in., 5/16 in., ⅜ in., 7/16 in. and ½ in. and 1 yarning iron, weight 9 lbs., price 24c lb.

Cold chisels of ⅞-in. octagon steel, per lb., 20c.

Diamond points, per lb., 18c.

Dog chisels handled, 2½, 3, 3½ and 4 lbs., 26c per lb.

Dog diamonds, handled, 4 lbs., each $1.20.

Bursting wedges, 8 inches long, 1½ in. bit, weight 2 lbs., 20c per lb.

Asbestos joint runners range from $1.00 for ¾ in. square for 2, 3 and 4 in. pipe to $9.25 for 1¼ in. square for 48 in. pipe.

Sewer Builders' Mauls.—Net prices for mauls for sewer builders, etc., with selected hickory handles and iron bound head range from $1.40 each for 6x8 and 6x9 in. sizes to $1.50 each for 7x9, $1.60 for 7x10 and $1.70 for 8x10 in.

Manhole Covers.—Current prices, f. o. b. New York for manhole covers are 3½ to 4 cents per lb. for standard shapes.

SMALL TRENCH TOOLS.

	Weight, Pounds.	Each.	Per Dozen.
Mauls	22	$2.28	$25.20
Maul, Rough	22	1.08	11.80
	26	1.20	12.80
Steel Shoes, open end	20	1.31	15.00
Steel Shoes, box	25	1.69	18.00
Cast Steel Plank Drawer	20	2.44	.....
Galvanized Cement Bucket	10	....	8.40
Oval Brick Pails, 11" depth, all iron		1.35	.....

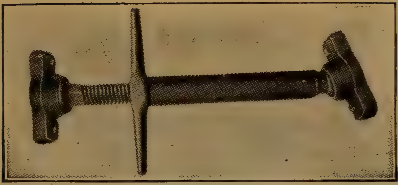


Fig. 220.

"DUNN" ALL IRON BRACES (STANDARD).

With 1½" Screw and 1½" Pipe.

Length of Brace Closed Overall.	Length of Screw.	Weight per Dozen Pounds.	Per Dozen Complete.
16"	11"	212	$23.00
18"	12"	220	23.00
21"	14"	240	24.00
24"	14"	252	24.00
27"	16"	270	26.00
30"	16"	280	26.00
3'	18"	300	27.00
3½'	18"	312	28.00
4'	18"	325	29.00
With 2" Screw and 2" Pipe—Extra Heavy Pattern.			
3'	18"	542	$51.00
3½'	18"	564	52.00
4'	18"	586	53.00
4½'	18"	608	54.00
5'	18"	630	55.00

Safety limit of extension 6 in. to 10 in., according to length of brace.

Sizes given are over all and when closed. Special sizes made to order.

Discount 20 per cent f. o. b. Pittsburgh, Pa.

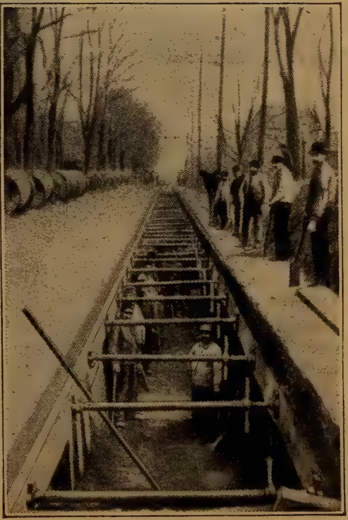


Fig. 221. Laying 48-inch Water Main at Buffalo, N. Y., Width of Cut, 5½ ft. Size of Brace Used, 4½ ft. (Closed).

PLOWS

GENERAL PURPOSE PLOWS.

Catalogue No.	No. of Horses.	Type.	Capacity.	Price.
B-C	1	Light	5 x10"	$6.50
10-O	1	Heavy	5½x11"	7.20
19	2 or more	Medium	6½x12"	8.00
20	2 or more	Medium	7 x13"	8.40
82	2	Light	7½x13"	8.40
83	2 or more	Medium	7½x14"	8.80
84	2 or more	Heavy	9 x16"	10.20

For wheel add $1.00, for jointer add $1.50, for rolling coulter add $12.50.

Fig. 222. Contractors' Two or Four Horse. Weight with Wheel, 205 Pounds.

RAILROAD OR GRADING PLOWS.

(Suited for Very Heavy Grading.)

Fig.	Horse.	Deep.	Wide.	Weight, Pounds.	Price.
222	2 to 4	5" to 9"	12"x15"	205	$10.00
223	4 to 8			310	23.33

Points for No. 1, price 30c, and for No. 99, price $3.35 each.

Subsoil Plow. (Fig. 224.) A two-horse plow with a capacity from 10 to 14 inches deep, fitted with wheels and adjustable handles; weight 143 lbs., price $11.60.

Pavement and Pick Plows. (Fig. 225.) Pavement pick plow for 4 to 6 horses; weight 280 lbs., price $16.67. Extra points $3.33 each.

Pavement Plow, 4 to 6 horses, adapted for tearing up cobble stones and macadam pavement; weight 255 lbs., price $21.00.

Fig. 223. Four to Eight Horse. Weight, with Shoe, 310 Pounds.

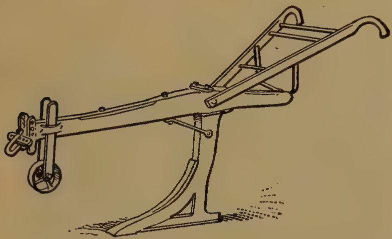


Fig. 224. Two Horse Subsoil Plow.

Fig. 225. Four or Six Horse. Weight, 280 Pounds.

Bull Dog Rooter Plow. (Fig. 226.) Very strong and suited for the heaviest kind of work; weight 290 lbs., price $25.50.

Fig. 226. Bull Dog Rooter Plow.

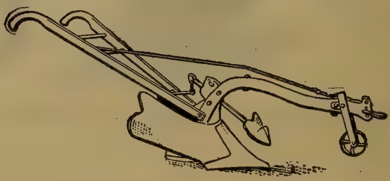


Fig. 227. Side Hill Plow.

Side Hill Plow. (Fig. 227.) For two or more horses, equipped with a shifting clevis, cuts 5 to 8 inches deep and 12 to 15 inches wide; weight 126 lbs., price $11.00.

The life of a heavy plow is 4 to 5 years where more than four horses are used; the cost of repairs may be 25 cents per working day.

RAILROAD OR GRADING PLOWS.

No. of Horses.	Weight, Pounds.	Cut, Inches.	Price, Each.	Extra Points, Each.
2 to 4	150	10	$19.50	$4.25
4 to 6	175	10	22.00	4.25
6 to 8	230	12	26.00	5.15
12 to 14	280	12	35.00	5.75

Contractors' or township plows, right or left hand, cutting a furrow 10 ins. wide and from 6 ins. to 12 ins. deep, and weighing 145 lbs., can be bought for $16.50 each. A heavier plow, weighing 205 lbs., costs $20 each. Extra points are not included in above price, but can be bought for $2.25 each extra. Road plows, all steel, with cast iron beam, cutting 12 ins. and weighing 170 lbs., can be bought for $21. Rooter or hard pan plows weighing 305 lbs. cost $30 each.

Fig. 228—Steel Beam Plow.

POST HOLE DIGGERS

Post Hole Diggers and Augers.—Net prices at Chicago for post hole diggers and augers are as follows:

Post Hole Diggers.

	Length Blade, Inches.	Wt. to Dozen, Pounds.	Price, Each.	Price per Doz.
Eureka, standard pattern......	9	110	$0.72	$7.20
Eureka, heavy pattern.........	9	140	1.05	10.50
Hexagon	9	120	.84	8.40
Champion	6	140	.60	6.00

Post hole augers with blades 6 in., 7 in., 8 in., or 9 in. can be bought for $1.00 each.

Fig. 229. Using Post Hole Augers to Dig Holes for Posts for Office Building, Forest Hills.

POWER

(See Boilers.)

Mr. Wm. O. Webber, a consulting engineer of Boston has published some very interesting and most important figures to show the comparative cost of gasoline, steam, gas and electricity for small powers. His data have been compiled on the basis of yearly operation, the year comprising 3,080 hours, and for purposes of work in the Northern climate these will have to be modified to suit the special case in point. I have, however, abstracted the tables without attempting to change them.

I.—COST OF GASOLINE POWER.

Size of plant in horsepower	2	6	10	20
Price of engine in place	$150.00	$ 325.00	$ 500.00	$ 750.00
Gasoline per B. H. P. per hour.....	⅓ gal.	¼ gal.	1/6 gal.	⅛ gal.
Cost per gallon....	$ 0.22	$ 0.20	$ 0.19	$ 0.18
= cost per 3,080 hours	$451.53	$ 924.00	$ 975.13	$1,386.00
Attendance at $1 per day.........	308.00	308.00	308.00	308.00
Interest, 5%........	7.50	16.25	25.00	37.50
Depreciation, 5%..	7.50	16.25	25.00	37.50
Repairs, 10%.....	15.00	32.50	50.00	75.00
Supplies, 20%.....	30.00	65.00	100.00	150.00
Insurance, 2%.....	3.00	6.50	10.00	15.00
Taxes, 1%.........	1.50	3.25	5.00	7.50
Power cost......	$824.03	$1,371.75	$1,498.13	$2,016.50

To these figures should be added charges on space occupied, as follows:

Value of space occupied	$100.00	$ 150.00	$ 200.00	$ 300.00
Interest, 5%.......	$ 5.00	$ 7.50	$ 10.00	$ 15.00
Repairs, 2%........	2.00	3.00	4.00	6.00
Insurance, 1%.....	1.00	1.50	2.00	3.00
Taxes, 1%.........	1.00	1.50	2.00	3.00
Total annual charge for space	$ 9.00	$ 13.50	$ 18.00	$ 27.00
Total cost per annum	$833.03	$1.385.25	$1,516.13	$2,043.50
Cost of 1 horsepower per annum 10-hour basis....	416.51	239.87	151.61	102.17
Cost of 1 horsepower per hour	0.1352	0.0780	0.0492	0.0331

II.—COST OF ELECTRIC CURRENT.

The costs for the electric current which are used in this table are figured from the discount table shown as follows:

Base price = 13½c per KW. hour. Discounts on Monthly Bill.

Monthly Bill.	Discounts.	Monthly Bill.	Discounts.
$ 5	10%	$100 to $125	40%
10 to $ 20	15%	125 to 150	45%
20 to 25	20%	150 to 175	50%
25 to 50	25%	175 to 200	55%
50 to 75	30%	200 to 500	60%
75 to 100	35%	500 and over	65%

For 2-horsepower plant:

$$\frac{3{,}080 \text{ hrs.} \times 2 \text{ H. P.} \times 0.746}{82\% \text{ Effic.}} = 5{,}604.10 \text{ KW. hr. per annum}$$

then

5,604.1 × $0.135 = $756.55, annual cost without discount.
Monthly bill = $63. Discount = 30%.
$756.55 × 70% = $529.56 = Annual cost.

For 6-horsepower plant:

$$\frac{3{,}080 \text{ hrs.} \times 6 \text{ H. P.} \times 0.746 \times \$0.135 \times 45\%}{86\% \text{ Effic.}} = \$976.00$$

Monthly cost = $180. Discount = 55%

For 10-horsepower plant:

$$\frac{3{,}080 \times 10 \times 0.746 \times 0.135 \times 40\%}{87\%} = \$1{,}425.00$$

Monthly cost = $298. Discount = 60%

For 20-horsepower plant:

$$\frac{3{,}080 \times 20 \times 0.746 \times 0.135 \times 35\%}{88.5\%} = \$2{,}450.00$$

Monthly cost = $585. Discount = 65%

Size of plant in H. P.	2	6	10	20
Cost of motor in place	$ 83.00	$118.00	$216.00	$270.00
With wiring, etc.	100.00	130.00	240.00	300.00
Cost of electricity, 3,080 hrs.	$529.56	$976.00	$1,425.00	$2,450.00
Attendance	20.00	30.00	50.00	50.00
Interest, 5%	5.00	6.50	12.00	15.00
Depreciation, 10%	10.00	13.00	24.00	30.00
Repairs, 5%	5.00	6.50	12.00	15.00
Supplies, 1%	1.00	1.30	2.40	3.00
Insurance, 2%	2.00	2.60	4.80	6.00
Taxes, 1%	1.00	1.30	2.40	3.00
Total cost per annum	$573.56	$1,037.20	$1,532.60	$2,572.00
Cost of 1 H. P. per annum, 10-hour basis	$286.78	$172.86	$153.20	$128.60
Cost of 1 H. P. per hour	$0.0928	$0.0558	$0.0497	$0.0417

III.—COST OF GAS POWER.

Illuminating gas used, 760 B. T. U. No estimate is made on the cost of gas power using producer gas, as it would not pay to put in a gas producer for so small a unit.

$1.50 per 1,000 cu. ft. of gas less 20%, if paid in 10 days = $1.20 net, gas 760 B. T. U.

Size of plant in H. P.	2	6	10	20
Engine cost if in place	$200.00	$375.00	$550.00	$1,050.00
Gas per H. P. in feet	30	25	22	20
Value of gas consumed, 3,080 hours	$221.76	$554.40	$843.12	$1,478.00
Attendance, $1 per day	308.00	308.00	308.00	308.00
Interest, 5%	10.00	18.75	27.50	52.50
Depreciation, 5%	10.00	18.75	27.50	52.50
Repairs, 10%	20.00	37.50	55.00	105.00
Supplies, 20%	40.00	75.00	110.00	210.00
Insurance, 2%	4.00	7.50	11.00	21.00
Taxes, 1%	2.00	3.75	5.50	10.50
Power cost	$615.76	$1,023.65	$1,387.62	$2,237.50
Annual charge for space	9.00	13.50	18.00	27.00
Total cost per annum	$624.76	$1,037.15	$1,405.62	$2,264.50
Cost of 1 H. P. per annum, 10-hour basis	$312.28	$172.86	$140.56	$113.22
Cost of 1 H. P. per hour	$0.1014	$0.0561	$0.0456	$0.0367

IV.—COST OF STEAM POWER.

Size of plant in H. P.	6	10	20
Cost of plant per H. P.	$250.00	$220.00	$200.00
Fixed charge, 14%	35.00	30.80	28.00
Coal per H. P. hour, in lbs.	20	15	12
Cost of coal at $5 per ton	$154.00	$103.00	$ 82.50
Attendance, 3,080 hours	75.00	50.00	30.00
Oil waste and supplies	15.00	10.00	6.00
Cost 1 H. P. per annum, 10-hr basis	$279.00	$194.80	$146.50
Cost of 1 H. P. per hour	$0.0906	$0.0832	$0.0475

Mr. Webber has elsewhere observed the fact that a gas engine of single cylinder type, which will operate on ⅛ gal. of fuel per H. P. at full load will perhaps require over a gallon of H. P. at a 10% load; and a small steam engine, which will run on 5 pounds of coal per H. P. per hour at full load may need 15 pounds at ¼ load.

Mr. W. O. Webber has also given, in the *Engineering Magazine*, some interesting detailed figures on the cost of steam plant installation, which are given in the following table:

COST OF INSTALLATION OF A 10-HORSEPOWER STEAM PLANT.

Land for engine and boiler room, 300 sq. ft. @ $1	$300.00	
Boiler and engine room building, 300 sq. ft. @ $1.50	450.00	
Chimney, 10"x40'	400.00	
		$1,150.00
10-horsepower boiler	241.00	
Boiler foundation and setting, 3,900 C. B. 500 F. B.	160.00	
Blow-off tank	31.00	
Damper and regulator	75.00	
Injector tank	10.00	
Water meter	40.00	
Piping for same	20.00	
Pump and vacuum	122.00	
Feed water heater	40.00	
Pipe covering	50.00	
		789.00
Engine, 7 by 10	$184.00	
Foundation for same	60.00	
Steam separator	35.00	
Oil separator	25.00	
Piping	95.00	
Freight and cartage	30.00	
		429.00
		$2,378.00

COST OF INSTALLATION OF A 60-HORSEPOWER STEAM PLANT.

Land for engine and boiler room		$2,500.00
Buildings for engine and boiler room		2,500.00
Chimney		1,200.00
80-horsepower boiler	$ 790.00	
Ash pan for boiler (below high tide level)	120.00	
Boiler and engine settings	1,282.00	
Blow-off tank	31.00	
Damper regulator	75.00	
Injector tank	10.00	
Water meter	60.00	
Piping for same	22.13	
Pump and receiver	146.50	
Feed water heater	70.40	
Pipe covering	70.75	
		2,677.78
Engine, 12 by 30	$1,065.00	
Pan for engine flywheel	72.00	
Steam separator	60.00	
Oil separator	41.80	
Piping, freight and cartage	1,026.41	
		2,265.27
Shafting in place	$ 550.00	
Belting in place	285.00	
		835.00
		$11,977.99

$11,977.99 ÷ 60 = $199.63 per H. P.

Mr. Wm. Snow has contributed to the engineering press some extremely useful tables of the various costs of steam plant for different sizes of installation.

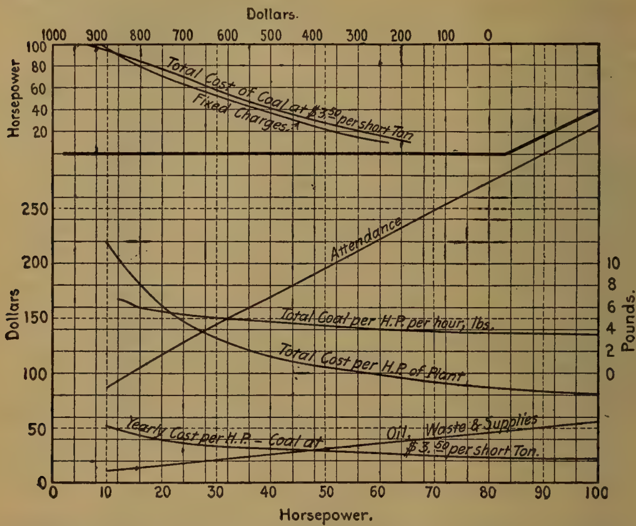


Fig. 230—Approximate Yearly Costs of Steam Power, 150 Days, 10 Hours per Day, Simple Condensing. Plotted from Data Compiled by Wm. E. Snow.

From his figures we have compiled the following three diagrams, which show graphically the effect of size of plant upon the various elements of cost.

FIRST COST AND COST OF OPERATING POWER PLANTS FOR DRIVING NORTH RIVER TUNNELS OF PENNSYLVANIA RAILROAD, NEW YORK CITY.

(Extract from a paper entitled "The New York Extension of the Pennsylvania Railroad North River Tunnels," by B. H. M. Hewett and W. L. Brown, Proceedings American Society of Civil Engineers, Vol. XXXVI, p. 690.)

Two power plants were constructed, one on each side of the river. The plants contained in the two power houses were almost identical, there being only slight differences in the details of arrangement due to local conditions. A list of the main items of the plant at one power house is shown in Table I. A summary of the first cost of one plant is given in Table II.

In order to give an idea of the general cost of running these plants, Tables III and IV are given as typical of the force em-

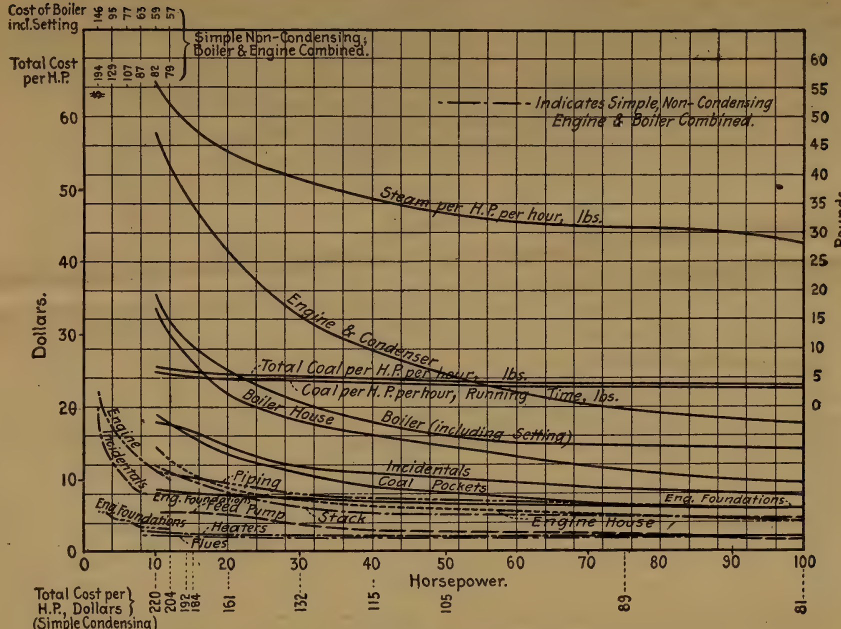


Fig. 231—Approximate Costs per Horsepower of Steam Power Plants Complete, Simple Condensing. Plotted from Data Compiled by Wm. E. Snow.

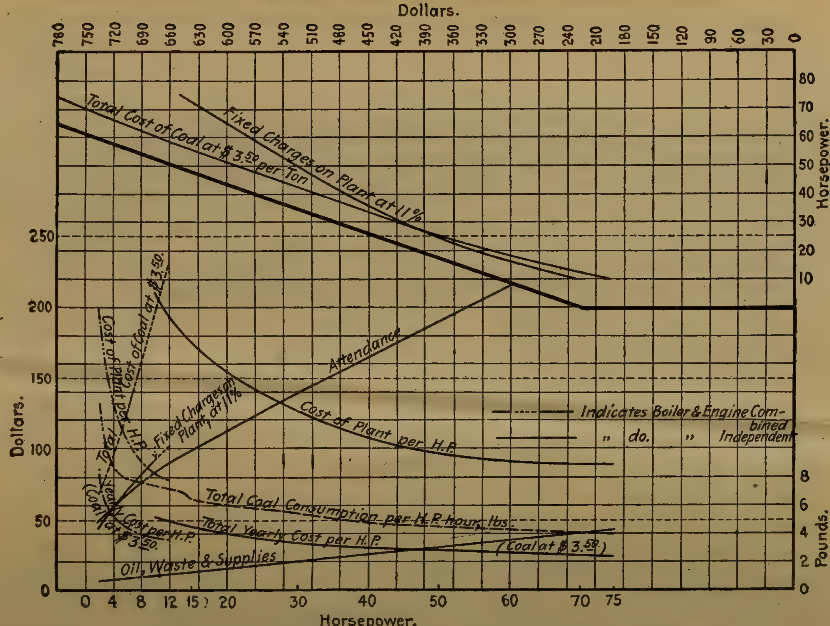


Fig. 232—Approximate Yearly Costs of Steam Power, 150 Days, 10 Hours per Day, Simple Non-Condensing. Plotted from Data Compiled by Wm. E. Snow.

ployed and the general supplies needed for a 24-hour run of one plant. Table III gives a typical run during the period of driving the shields, and Table IV is typical of the period of concrete construction. In the latter case the tunnels were under normal air pressure. Before the junction of the shields both plants were running continuously; after the junction, but while the tunnels were still under compressed air, only one power house plant was operated.

TABLE I—PLANT AT ONE POWER HOUSE.

Description of Item.	Cost.
3 500-h.p. water-tube Sterling boilers	$ 15,186
2 feed pumps, George F. Blake Manufacturing Co	740
1 Henry R. Worthington surface condenser	6,539
2 electrically driven circulating pumps on river front	5,961
3 low-pressure compressors, Ingersoll-Sergeant Drill Co.	33,780
1 high-pressure compressor, Ingersoll-Sergeant Drill Co.	6,665
3 hydraulic power pumps, George F. Blake Mfg. Co	3,075
2 General Electric Co.'s generators coupled to Ball and Wood engines	7,626
Total cost of main items of plant	$ 79,572

TABLE II—SUMMARY OF COST OF ONE PLANT.

Total cost of main items of plant	$ 79,572
Cost of four shields (including installation, demolition, large additions and renewals, piping, pumps, etc.)	103,560
Cost of piping, connections, drills, derricks, installation of offices and all miscellaneous plants	101,818
Cost of installation, including preparation of site	39,534
Total prime cost of one power house plant	$324,484

TABLE III—COST OF OPERATING ONE POWER HOUSE FOR 24 HOURS DURING EXCAVATION AND METAL LINING.

Labor.	Rate per Day.	Amount.
6 Engineers	$3.00	$ 18.00
6 Firemen	2.50	15.00
2 Oilers	2.00	4.00
2 Laborers	2.00	4.00
4 Pumpmen	2.75	11.00
2 Electricians	3.50	7.00
1 Helper	3.00	3.00
Total per day		$ 62.00
Total for 30 days		$1,860.00

Supplies.	Rate per Day.	Amount.
Coal (14 tons per day)	$3.25	$ 45.50
Water	7.00	7.00
Oil (4 gals. per day)	0.50	2.00
Waste (4 lbs. per day)	0.07	0.28
Other supplies	1.00	1.00
Total per day		$ 55.78
Total for 30 days		1,673.00
Total cost of labor and supplies for 30 days		3,533.00

TABLE IV—COST OF OPERATING THE ONE PLANT FOR 24 HOURS DURING CONCRETE LINING.

Labor.	Rate per Day.	Amount.
2 Engineers	$3.00	$ 6.00
2 Firemen	2.50	5.00
2 Pumpmen	3.00	6.00
1 Foreman electrician	6.00	6.00
1 Electrician	3.00	3.00
1 Laborer	2.00	2.00
Total per day		$ 28.00
Total for 30 days		840.00

Supplies.	Rate per Day.	Amount.
Coal (14 tons per day)	$ 3.15	$ 44.10
Oil (4 gals. per day)	0.50	2.00
Water	13.00	13.00
Other supplies	2.00	2.00
Total per day		$ 61.10
Total for 30 days		1,833.00
Total cost of labor and supplies for 30 days		2,673.00

PUMPS

I have taken the following classification of pumps from Turneaure and Russell's "Public Water Supplies":

Pumps may be classified in various ways, but for the consideration of their mechanical action they may be best considered under the following heads:

1. Displacement-pumps.
2. Impeller-pumps.
3. Impulse-pumps.
4. Bucket-pumps.

The various subdivisions of the classification are shown in table below:

- Pumps
  - Absolute volume displaced — Displacement
    - Recipro-cating
      - Action
        - Double
        - Single
      - Class
        - Piston
        - Plunger
          - Inside-packed
          - Outside-packed
          - Center-packed
      - Type
        - Power
          - Single
          - Duplex
          - Triplex
        - Steam
          - Application
            - High-pressure
            - Compound
          - Arrangement
            - Direct-acting
            - Crank & flywheel
            - Compensator
        - Hydraulic
          - Direct-acting
          - Crank and fly-wheel
      - Arrangement
        - Vertical
        - Horizontal
      - Use
        - Surface (suction)
        - Submerged or deep well
    - Rotary
    - Air-displacement
    - Steam-vacuum
    - Continuous-flow
      - Screw
      - Chain
      - U pump
      - Double-acting
  - Impeller — Continuous applica-tion through some mechanical agency or medium
    - Centrifugal
      - Impeller
        - Opened
        - Closed
      - Case
        - Side suction
        - Double suction
      - Arrangement
        - Horizontal
        - Vertical
    - Jet
      - Water
      - Steam
      - Air
  - Impulse (as name implies)—Water-ram
  - Bucket (receptacle alternately filled and emptied)
    - Wheel
    - Band

CENTRIFUGAL PUMPS.

The centrifugal pump (Figs. 233-236) has been developed and perfected during the past seven years, so that it is now recognized as a simple, reliable pump of great range.

The principal trouble with a centrifugal pump, especially when the pump is at a substantial height above the water, is in starting it. When the pump sucks it must be reprimed and started again. Therefore, if the amount of water to be handled

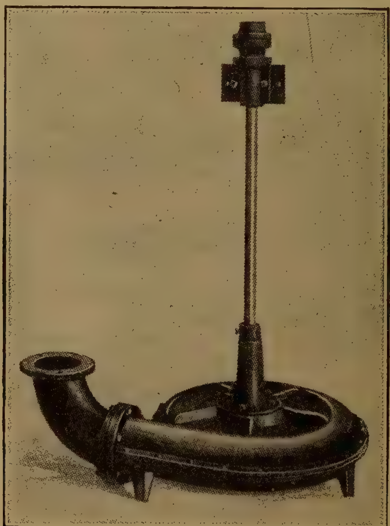


Fig. 233. Submerged Type.

is not as great as the minimum capacity there will be many stops and knock-offs to prime. Before starting up a steam pump, especially in cold weather, it should be well warmed up by live steam from the end of a hose in order to thaw out any ice that may have formed in the cylinders and to give the iron parts a chance to expand gradually.

Iron Vertical Centrifugal Pumps, submerged or suction type, furnished complete with short shaft and coupling, one bearing, pulley for connecting shaft and discharge elbow, are used extensively for irrigation purposes, sewage pumping, and for any place where a pump may be placed in a pit. Suitable for elevating water 50 to 60 feet.

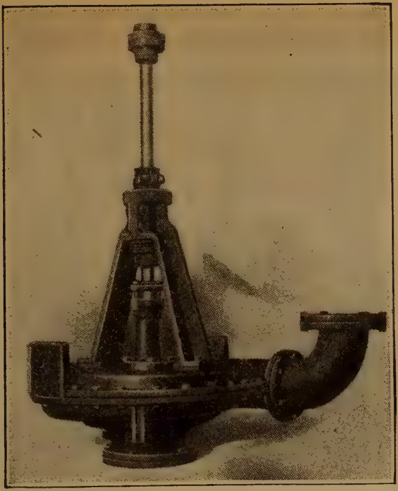


Fig. 234. Suction Type.

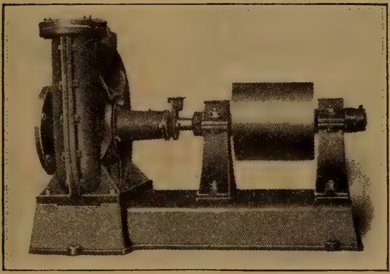


Fig. 235.

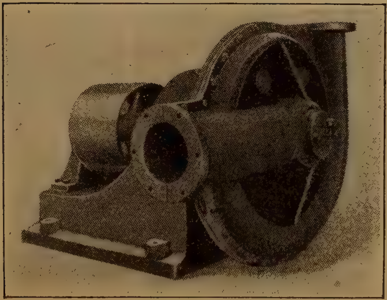


Fig. 2́36.

TABLE 136—IRON VERTICAL CENTRIFUGAL PUMPS.

Discharge	H. P. Required for Each Ft. Elev.	Diam. & Face of Pulley (Ins.)	Capacity per Min. (Gals.)	Floor Space Required.	Shipping Wt. (Lbs.) Submerged Type	Suction Type	Price Complete Submerged Type	Suction Type
1½	.058	5x 6	70	2′ 9″	120	135	$ 20.00	$ 30.00
2	.10	7x 8	120	3′ 4″	198	250	32.00	50.00
3	.22	7x 8	260	3′ 6″	235	340	47.00	73.00
4	.30	8x10	470	4′ 0″	380	495	55.00	85.00
5	.45	10x10	735	4′ 7″	605	785	70.00	105.00
6	.59	12x12	1,050	4′ 7″	740	1,050	85.00	140.00
10	1.52	20x12	3,000	5′ 5″	1,430	1,925	165.00	275.00
12	2.00	24x14	4,200	6′ 0″	2,640	3,000	210.00	350.00
*12	2.00	20x12	4,200	3′ 9″	2,000	2,500	185.00	325.00
18	4.50	36x18	10,000	7′ 0″	6,000	7,000	470.00	790.00
*18	4.50	30x16	10,000	6′ 6″	2,900	3,300	420.00	710.00

* Refers to low-lift pumps for elevations up to 25 feet.

Iron Horizontal Centrifugal Pumps for belt drive. A pump used extensively for all purposes.

TABLE 137—IRON HORIZONTAL CENTRIFUGAL PUMPS.

Discharge	Suction	Capacity per Min. (Gals.)	H. P. for Each Ft. of Elevation	Diam. & Face of Pulley (Ins.)	Floor Space (Ins.)	Shipping Wt. (Lbs.)	Price
1½	2	70	.058	6x 6	17x31	175	$ 22.50
2	3	120	.10	8x 8	23x37	350	37.50
3	4	260	.22	8x 8	25x39	415	55.00
4	5	470	.30	10x10	29x41	615	65.00
5	6	735	.45	12x12	34x54	940	82.50
6	8	1,050	.59	15x12	37x55	1,180	100.00
10	12	3,000	1.52	24x22	51x69	2,610	197.50
12	15	4,200	2.00	30x14	63x71	3,615	250.00
*12	12	4,200	2.00	20x12	51x59	2,800	250.00
18	20	10,000	4.50	40x16	93x103	9,000	650.00
*18	20	10,000	4.50	30x16	66x72	5,800	575.00
*24	24	15,000	6.50	48x20	90x98	10,800	1,075.00
24	24	15,000	6.50	48x36	94x137	13,000	1,500.00

* Low-lift pumps for elevations up to 25 feet.

The above pump, fitted with a direct connected vertical steam engine costs: 4 in. side suction, 4x4 in. engine $210.00; weight, 1,290 lbs. 5 in. side suction, 5x5 in. engine, $224.00; weight, 1,440 lbs. 6 in. side suction, 6x6 in. engine, $238.00; weight, 1,570 lbs.

Double Suction Iron Pumps, built extra heavy for elevating water to great heights.

DOUBLE SUCTION IRON PUMPS.

Discharge	Suction	Capacity per Min. (Gals.)	H. P. Required for Each Ft. Elevation	Diam. & Face of Pulley (Ins.)	Floor Space (Ins.)	Shipping Wt. (Lbs.)	Price
1½	2	70	.058	7x 8	20x30	290	$ 30.00
2	3½	120	.10	8x 8	26x35	510	45.00
3	3½	260	.22	8x 8	27x38	615	67.50
4	5	470	.30	10x10	33x40	900	87.50
5	6	735	.45	12x12	37x49	1,530	125.00
6	7	1,050	.59	15x12	43x51	1,730	175.00
10	11	3,000	1.52	24x12	57x73	3,325	387.50
12	13	4,200	2.00	30x14	69x82	5,500	560.00
18	20	10,000	4.50	40x16	90x80	9,300	1,025.00

Direct Connected Dredging Pumps, complete with suction and discharge elbow, flap valve and steam primers, lubricator and oil cups. Cast iron impellor. The shipping weight and the price may vary 20 per cent from the averages given in table.

TABLE 138—DIRECT CONNECTED DREDGING PUMPS.

No. Pump & Diam. of Suction & Discharge	Total Head	Engine Description	Size of Cylinders		Capacity, Yds. per Hr. (20% Solids)	Largest Diam. of Solids (Ins.)	Weight (Lbs.)	Price
			Diam.	Stroke				
4	15	Single	5	5	30	2	1,600	$ 224.00
4	20	Single	6	6	30	2	1,800	240.00
4	25	Double	5	5	30	2	2,000	328.00
6	15	Single	6	6	60	4	2,500	285.00
6	20	Single	7	7	60	4	2,700	316.00
6	25	Double	6	6	60	4	3,000	415.00
8	15	Single	9	9	125	6	4,750	501.00
8	20	Double	7	7	125	6	5,800	567.00
8	25	Double	8	8	125	6	6,500	723.00
10	15	Single	10	10	200	8	7,500	645.00
10	20	Double	9	9	200	8	9,500	822.00
10	25	Double	10	10	200	8	10,500	1,000.00
12	15	Single	12	12	300	10	10,000	892.00
12	20	Double	10	10	300	10	12,800	1,069.00
12	25	Double	12	12	300	10	16,000	1,485.00

Belt Driven Sand and Dredging Pumps, complete except for pipe or hose.

TABLE 139—BELT DRIVEN PUMPS.

Catalog No.	Diam. of Suction and Discharge	Capacity, Yds. per Hr. (20% Solids)	H. P. Required per 10' Head.	Diameter and Face of Pulley.	Shipping Weight (Lbs.)	Largest Diam. of Solids (Ins.)	Price
4	4	30	4	12x12	1,200	2	$108.00
6	6	60	8	18x12	1,850	4½	155.00
8	8	125	15	24x12	3,600	6	245.00
10	10	200	25	30x14	4,550	8	310.00
12	12	300	30	40x16	8,000	10	435.00

TABLE 140—WEIGHTS, DIMENSIONS AND PRICES OF DIRECT ACTING STEAM PUMPS.

No.	Size of Cyl., inches: Steam Cyl.		Water Piston	Stroke	Maximum Gals. per Min.	Working Gals. per Min.	Weight (Lbs.)	Price
1	9		5¼	10	192	100	1,500	$ 219.00
2	6	9	5¼	10	192	100	3,100	402.00
3	14		10¼	10	750	500	5,400	543.00
4	14		10	15	792	500	6,400	600.00
5	12	18½	10¼	10	753	500	8,200	810.00
6	12	17	10	15	792	500	9,500	927.00
7	17		14	15	1,500	1,000	13,000	1,215.00
8	14	20	14	15	1,500	1,000	16,000	1,530.00
9	20	29	14	18	2,250	1,500	27,000	2,820.00
10	19	30	15	24	3,000	2,000	40,000	4,080.00
11	10		6	10	220	150	3,500	260.00
12	10		7	10	300	225	4,000	450.00
13	12		8½	10	485	325	4,300	550.00
14	14		10¼	10	635	425	6,500	750.00
15	10	16	8½	10	485	325	7,300	900.00
16	12	17	8½	15	635	425	9,600	1,150.00
17	12	17	10¼	15	855	600	11,000	1,320.00
18	14	12	12	15	1,200	800	15,200	1,500.00
19	4½		3¾	4	56	38	300	75.00
20	5¼		4¾	5	106	70	500	95.00
21	6		5¾	6	172	115	660	125.00
22	6		7½	6	295	195	950	180.00
23	7½		6	10	256	170	1,200	210.00
24	7½		7	10	352	235	1,500	275 00
25	9		8½	10	522	350	1,900	350.00
26	12		10¼	10	760	505	4,300	550.00
27	12		12	10	1,045	695	5,100	650.00

No. 1 is a piston pump, suitable for general service for 150 lbs. water pressure, where the water contains small quantities of grit or foreign material or where there is a long suction lift and no foot valve.

No. 2 is a pump of the compound piston pattern for general service for 150 lbs. A saving of 30 to 35 per cent in coal may be expected from the use of compound steam cylinders.

No. 3 is a piston pattern pump, suitable for the same service as No. 1.

No. 4 is a plunger and ring pump used in general water supply boiler feeding, etc.

No. 5 is a compound plunger and ring pump for general service.

No. 6 is of the same type as No. 5.

No. 7 is a plunger and ring pump for general service.

No. 8 is a plunger and ring pump for general service.

Nos. 9 and 10 are either piston or plunger and ring pumps with semi-rotative steam valves. These are suitable where fuel economy is essential or where a large amount of water has to be pumped.

Nos. 12 to 18, inclusive, are packed plunger pumps, suitable for rough and heavy service, where the water contains considerable quantities of sand and grit, and where the working pressure to be pumped against is over forty pounds per square inch, and, as in mine work, where it is important that moving parts can be repacked quickly.

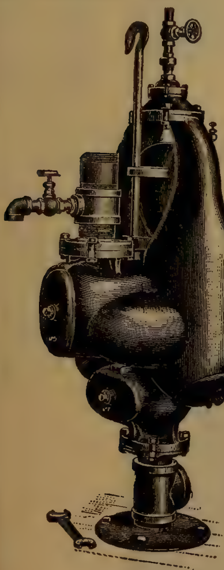


Fig. 237.

Nos. 19 to 27, inclusive, are piston pumps for contractors' use where the total water pressure to be pumped against is not over 35 to 50 lbs. per square inch.

PULSOMETER.

A very well known steam operated vacuum pump is the one illustrated in Fig. 237. It consists of two bottle shaped cylinders with the necessary valve inlet and outlet pipes. The operation of this pump is sustained by alternate pressure and vacuum. Steam, cushioned by a layer of air automatically admitted, is brought to bear directly upon the liquid in the pump chambers and forces it out through the discharge pipe; the subsequent rapid condensation of the steam, effected by the peculiar construction of the pump, forms a vacuum in the working chambers, into which atmospheric pressure forces a fresh supply of liquid through the suction pipe. This action is maintained quite automatically, and is governed by a self-acting valve ball in the neck of the pump, which obeys the combined influences of steam pressure on one side and vacuum on the other. The valve ball

oscillates from its seat in the entrance to one chamber to its seat in the entrance to the other chamber, thereby distributing the steam.

This pump will do all classes of rough service raising water up to 75 feet elevation. It has no piston, no packing, no oil, and seldom breaks down, but is very uneconomical of steam.

TABLE 141—PULSOMETER PUMPS.

	Size of Pipe (Ins.)			Capacity in Gals. per Min. at Different Elevations and Boiler H. P.				Price, f. o. b. New York		
Catalog No.	Steam	Suction	Discharge	25 Ft.	50 Ft.	75 Ft.	H. P.	Flat Valve (Standard)	Ball Valve (Special)	Weight (Lbs.)
2	¼	1½	1½	20	17	13	4	$ 68	$ 71	95
3	⅜	2	2	60	50	38	5	90	95	140
4	½	2½	2½	100	80	65	6	135	142	295
5	½	3	3	180	160	115	9	158	168	430
6	¾	3½	3½	300	265	200	12	203	217	570
7	¾	4	4	425	375	275	15	248	270	745
8	1	5	5	700	625	450	25	360	396	1,375
9	1½	11	6	1,000	900	650	35	450	495	2,100
10	2	8	8	2,000	1,800	1,400	70	900		3,800

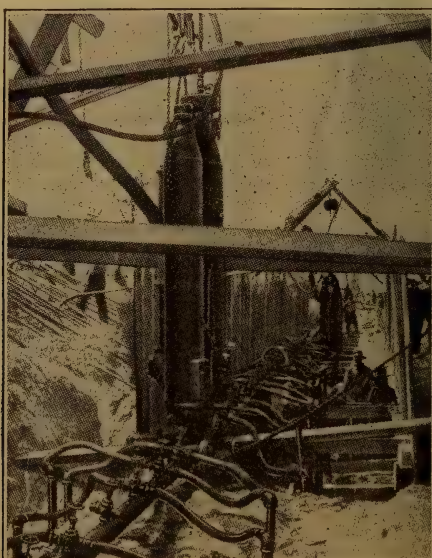


Fig. 238. Emerson Pumps Fighting Three Miles of Quicksand at Gary, Ind.

Each pump is furnished complete with either basket or mushroom strained steam and release valve connection, and pump hook for suspending when necessary, but no piping.

A pump working on similar principles, but which may be slightly more economical in steam consumption and works against greater heads, is illustrated in Figs. 238 and 239. The main differences are in the steam distribution, which, in this type, is governed by a simple engine, and in the necessity of oil for

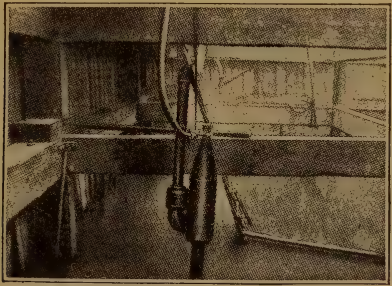


Fig. 239. A Junior Emptying a Cofferdam.

lubrication. These pumps will work, admitting 30 per cent of air or 25 per cent of grit, and a continuous run of four months has been recorded. They are especially valuable in quicksand and wherever the quantity of water is variable. The cost of repairs is nominal.

These pumps are made in two types; the standard consists of two vertical cylinders, each with a discharge and suction valve, topped by one simple, three-cylinder horizontal engine, with the necessary air cocks, lubricator and condenser piping, but no steam, suction or discharge pipe is supplied.

TABLE 142—CAPACITY, DIMENSIONS AND PRICES.
(See Fig. 238.)

Cat. No.	Size of Pipe (Ins.)			Capacity in Gals. per Min. at Various Heads, and Boiler H. P. Necessary										Greatest Dimensions (Ins.)			
				25′ Head		40′ Head		60′ Head		100′ Head		150′ Head					
	Steam	Suction	Discharge	Gals.	H. P.	Gals.	H. P.	Gals.	H. P.	Gals.	H. P.	Gals.	H. P.	Breadth	Height	Weight	Price
1	¾	3	2½	225	7	212	10	194	12	158	14	113	11	16½	97½	950	$ 245
2	1	4	3	415	13	390	18	357	22	290	25	208	19	21½	104	1,375	315
3	1¼	5	4	725	22	681	31	624	38	508	42	363	33	26	113	1,900	450
4	1½	6	5	1,200	36	1,128	51	1,032	63	840	70	600	54	29½	127	3,100	630
5	2	8	6	2,100	63	1,974	88	1,806	109	1,470	121	1,050	94	43¼	132	4,400	1,035
6	2½	10	8	3,275	96	3,079	137	2,817	171	2,293	189	1,638	146	51½	135	5,400	1,530

The Junior consists of a single cylinder, a steam piston valve, suction valve, discharge valve, condenser pipe, check valve and stop cock, and is furnished with the patented foot valve and quick cleaning strainer.

Cat. No.	Size of Pipes (Ins.) Steam.	Suction.	Dis'ge.	Capacity in Gals. per Minute.	Greatest Dimensions. Br'dth.	H'ght.	Weight, Lbs.	Price.
A	½	3	2½	100	14½	47	219	$100
B	¾	4	3	150	17½	47	290	125
C	¾	5	4	200	21	47	410	175

Capacities stated in table in gallons per minute and per hour are calculated on a head or lift of 20 feet. These capacities diminish at the rate of about 6 per cent for each 10 feet of additional head up to 100 feet, the highest lift.

A Double Acting Force Hand Pump for filling tank wagons from brooks or other water sources has a capacity, with one man pumping, of one to two barrels per minute. Maximum total lift and force, 50 feet; maximum lift 25 feet, cylinder diameter 5 inches, stroke 5 inches, capacity per stroke 0.85 gallons. Suction hose 2 inches, discharge hose 1 inch; price of pump, with strainer, hose-couplings and clamps, but no hose, $8.00.

Lift and Force Diaphragm Pump, No. 3, one man pumping, capacity, 4,000 gallons per hour; price, with 15 feet of hose, $42.00; with 20 feet of hose, $48.00. No. 4, two men pumping, capacity 6,000 gallons per hour; price, with 15 feet of hose, $61.50, with 20 feet of hose, $70.00. Diaphragm pumps are suited

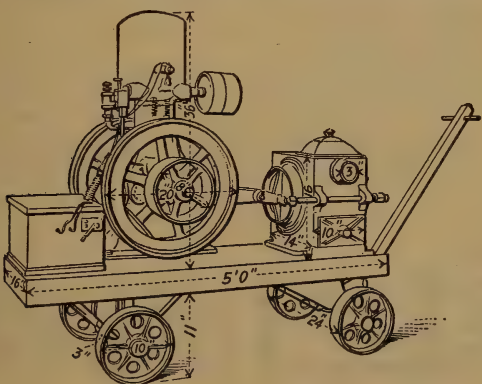


Fig. 240.

for general construction work, where the pumping is intermittent and the amount of water to be raised is small. The life of the pump depends on the care it is given and the amount of

grit the water contains. In very gritty water a diaphragm wears out in two or three weeks. These cost $1.30 each; extra strainers, which are sometimes broken by careless handling, cost $1.35 each. A set of brass hose-couplings costs $3.00.

Lift and Force Diaphragm Pump, No. 6, capacity 1,000 gallons per hour with one man working; weight 50 lbs.; price, with 10 feet of suction and 25 feet of connection hose, $54.00. No. 8, 4,000 gallons per hour with two men pumping; weight, 270 lbs.; price, $104.50. No. 10, 6,000 gallons per hour with two men pumping; weight, 395 lbs.; price, $139.75. Pumps alone, No. 6, $25.00; No. 8, $70.00; No. 10, $90.00. Pumps, with 20 feet of suction hose and 200 feet of connection hose, No. 6, $123.50; No. 8, $200.00; No. 10, $276.00.

The above pumps are especially suitable in mining prospecting or for any work where the water contains as much as 50 per cent of solids. These pumps will handle grout and quicksand.

A Diaphragm Pump, known as No. 3 Contractors' Mud Pump (Fig. 240), with double diaphragms, and a gasoline engine rated at 3 H. P., and having a speed of 500, all mounted on a truck, equipped with 15 feet of 3 inch spiral wire suction hose and 25 feet of discharge hose, with brass couplings and strainer, tools, etc., costs $300.00. The capacity of this pump is from 6,000 to 8,000 gallons per hour of water containing a considerable amount of sand, sewage and gravel. It is guaranteed for one year; weight, 1,000 lbs.; space occupied 2 feet by 5 feet.

Suction or Bilge Pump, consisting of a tin pipe with a plunger worked by hand.

2 in. diameter, per foot	$0.45
2½ in. diameter, per foot	.50
3 in. diameter, per foot	.55
3½ in. diameter, per foot	.60
4 in. diameter, per foot	.65

Pumps less than 5 feet long charged as 5 feet.

Special Pump—Fig. 241 is a sectional view of the Marsh Steam Pump, and shows the steam valve in position, the steam and

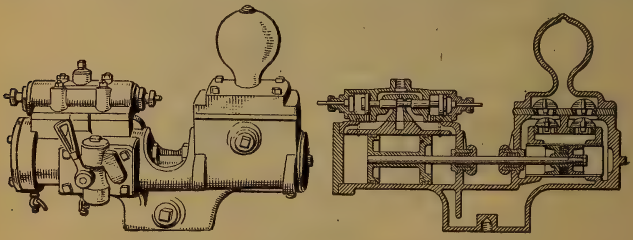


Fig. 241. The Improved Marsh Steam Pump.

water pistons, manner of packing, etc. The steam valve is made of brass, and though nicely fitted, moves freely in the central

bore of the steam chest. It has no mechanical connections with other moving parts of the pump, but is actuated to admit, cut off and release the steam by live steam currents, which alternate with the reciprocations of the piston. Each end of the valve is made to fit the enlarged bore of the steam chest, and it is due to those enlarged valve heads, which present differential areas to the action of steam, and the perfect freedom of the valve to move without hindrance from other mechanical arrangements or parts, that the flow of steam into the pump is automatically regulated. Because the pump is so regulated it can never run too fast to take suction; or, should the water supply give out when the throttle valve is wide open, no injury can occur to the

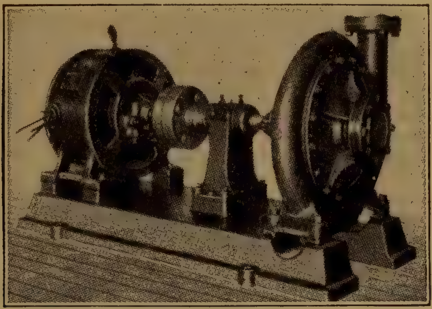


Fig. 242. Standard Side Suction Volute Pump.

moving parts. The steam valve does not require setting. The steam piston, as shown, is double, and each head is provided with a metal packing ring, the interior space constituting a reservoir for live steam pressure, supplied by the live steam pipe through a drilled hole shown by dotted lines. At each end of the steam cylinder are similar holes leading to each end of the steam chest, which, together with the centrally drilled hole and the space between the piston heads, constitute positive means for tripping or reversing the valve with live steam.

Size.	Gallons per Hour.	Horse-power.	Inches Floor Space.	Weight. Lbs.	Price.
B	200	36	7x12	40	$11.50
BB	400	60	8x16	75	14.00
C	500	75	10x22	145	25.00

RAILS AND TRACKS

The price of rails at Pittsburg and other centers varies from $27 to $35 per ton.

The following prices were current in the summer of 1910 on lots of 500 tons and over with the necessary fastenings, f. o. b. car at works, Chicago:

Standard quality No. 1 Bessemer rails, $28 per gross ton.

Standard quality No. 1 open hearth rails, $30 per gross ton.

Angle bar splices, 1.50 cts. per lb.

Spikes, 1.85 cts. per lb.

Bolts with square nuts, 2.45 cts. per lb.

Bolts with hexagon nuts, 2.60 cts. per lb.

The prices mentioned contemplate furnishing rails in 30-ft. lengths with 10 per cent of shorts, diminishing by even feet down to 24 feet. Where rails are required in 60-ft. lengths, add $2 per ton to the above prices. If ordered in lots less than 500 tons down to carloads, there is an additional cost of $2 per ton to the prices mentioned above.

Other quotations on light rails at Chicago are as follows:

	Per Ton
40 to 45-lb.	$27.00
30 to 35-lb.	27.75
16, 20 and 25-lb.	28.00
12-lb.	29.00

The following quotations are per gross ton delivered at Chicago:

Relaying rails, standard sections	$23.00	to	$25.00
Old iron rails	14.00	to	19.50
Old steel rails, less than 3 ft	12.50	to	17.50

The A. S. C. E. rail sections are most generally used and their dimensions are as follows:

Wt. Rail (Lbs. per Yd.)	Base (Ins.)	Tread (Ins.)	Wt. Rail (Lbs. per Yd.)	Base (Ins.)	Tread (Ins.)
8	1 9/16	13/16	55	4 1/16	2 1/4
12	2	1	60	4 1/4	2 3/8
14	2 1/16	1 1/16	65	4 7/16	2 13/32
16	2 3/8	1 11/64	70	4 5/8	2 7/16
20	2 5/8	1 11/32	75	4 13/16	2 15/32
25	2 3/4	1 1/2	80	5	2 1/2
30	3 1/8	1 11/16	85	5 3/16	2 9/16
35	3 5/16	1 3/4	90	5 3/8	2 5/8
40	3 1/2	1 7/8	95	5 9/16	2 11/16
45	3 11/16	2	100	5 3/4	2 3/4
50	3 7/8	2 1/8			

One flat car will hold about 60 rails of 80 lbs. section.

The ordinary R. R. rails are classified about as follows:

I. Fit for main track on a standard railroad.

II. Sides worn from curves but perfectly smooth.

III. In good condition but with battered ends which can be cut off and the bolt holes rebored.

IV. Fit only for sidings.

TABLE 143—WEIGHTS PER MILE OF RAIL AND FASTENINGS, SINGLE TRACK.

Weight of rail, pounds per yd.	Section No.	Number of pairs of splice bars.	Number of bolts.	Number of spikes	Weight of splice bars, gr. tons.	Weight of bolts, gr. tons.	Weight of spikes, gr. tons.	Total weight of fastenings, gr. tons.	Weight of rails, gr. tons.	Total weight of rails and fastenings, gr. tons.	Specification of length of rails, feet.
8	..	364	1456	10640	0.33	0.07	0.43	0.83	12.57	13.40	90%—30 ft. long and 10% short, down to 20 ft.
9	..	364	1456	10640	0.375	0.07	0.43	0.875	14.14	15.015	
10	..	364	1456	10640	0.42	0.07	0.43	0.92	15.71	16.63	
12	9	364	1456	10640	0.56	0.15	0.77	1.48	18.86	20.34	
14	8	364	1456	10640	0.56	0.15	0.77	1.48	22.00	23.48	
16	7	364	1456	10640	0.71	0.15	0.81	1.67	25.14	26.81	
20	6	364	1456	10640	0.79	0.16	1.53	2.48	31.43	33.91	
25	5	364	1456	10640	0.93	0.16	1.59	2.68	39.29	41.97	
30	4	364	1456	10640	1.70	0.30	1.59	3.59	47.14	50.73	
35	3	364	1456	10640	1.97	0.30	1.78	4.05	55.00	59.05	
40	2	364	1456	10640	2.62	0.47	1.94	5.03	62.86	67.89	
45	1	364	1456	10640	3.04	0.47	2.79	6.31	70.71	77.02	
50	A.S.C.E.	326	1304	10640	3.71	0.44	2.80	6.95	78.57	85.52	90%—30 ft. long, 10% short, varying by even feet down to 24 ft.
55	A.S.C.E.	326	1304	10640	4.20	0.46	2.80	7.46	86.43	93.89	
60	A.S.C.E.	326	1304	10640	4.71	0.46	2.80	7.97	94.29	102.26	
65	A.S.C.E.	326	1304	10640	5.17	0.48	2.80	8.45	102.12	110.57	
70	A.S.C.E.	326	1956	10640	7.96	0.71	2.80	11.47	110.00	121.47	
75	A.S.C.E.	326	1956	10640	8.52	0.74	2.80	12.06	117.86	129.92	
80	A.S.C.E.	326	1956	10640	9.07	0.75	2.80	12.62	125.71	138.33	

FISHPLATES AND BOLTS REQUIRED FOR ONE MILE SINGLE TRACK

Length of Rail.	Complete Joints.	Length of Rail.	Complete Joints.
All 21 feet	503	All 30 feet	352
All 24 feet	440	90 per cent., 30 feet 10 per cent., shorter	358
All 26 feet	406		
All 28 feet	377		

Each joint consists of two plates and four bolts and nuts. Therefore the number of plates required is twice as many as the number of complete joints, and the number of bolts required is four times as many. If six bolts are required for a joint, then the number of bolts will be six times the number of complete joints.

RAILROAD SPIKES.

Size Measured Under Head.	Average Number per Keg of 200 Pounds.	Ties 2 Feet between Centers, 4 Spikes per Tie Needed per Mile.	Rail Used, Weight per Yard.
6 x 9/16	320	6600 pounds—32 kegs	
5½ x 9/16	375	5870 pounds—30 kegs	45 to 100
5 x 9/16	400	5170 pounds—26 kegs	40 to 56
5 x ½	450	4660 pounds—23½ kegs	35 to 40
4½ x ½	530	3960 pounds—20 kegs	25 to 35
4½ x 7/16	680	3110 pounds—15½ kegs	25 to 35
4 x ½	600	3520 pounds—17⅔ kegs	25 to 35
4 x 7/16	720	2910 pounds—14¾ kegs	25 to 35
4 x ⅜	1000	2090 pounds—10½ kegs	16 to 25
3½ x ½	800	2200 pounds—11 kegs	16 to 25
3½ x 7/16	900	2350 pounds—12 kegs	16 to 25
3½ x ⅜	1190	1780 pounds— 9 kegs	16 to 25
3 x ⅜	1240	1710 pounds— 8½ kegs	16 to 25
2½ x ⅜	1342	1575 pounds— 7⅞ kegs	12 to 16

PERMANENT SWITCHES.

Wt. of rail, lbs. per yard.	Length of switch points.	Number and style of frog.	Weight of complete switch, pounds.	Price.
12	5′ 0″	4 Plate	215	$21.40
16	5′ 0″	4 Plate	260	23.10
20	5′ 0″	4 Plate	310	25.20
20	7′ 6″	4 Plate	360	27.50
25	7′ 6″	4 Plate	425	29.85
25	7′ 6″	5 Plate	470	31.08
30	7′ 6″	4 Plate	485	32.00
30	10′ 0″	5 Plate	585	35.05
35	7′ 6″	4 Plate	550	34.00
35	10′ 0″	5 Plate	665	37.15
40	10′ 0″	5 Cast filled and bolted	740	38.40
40	12′ 0″	6 Cast filled and bolted	885	43.25
40	15′ 0″	7 Cast filled and bolted	990	46.85
45	10′ 0″	5 Cast filled and bolted	840	42.00
45	12′ 0″	6 Cast filled and bolted	1005	47.25
45	15′ 0″	7 Cast filled and bolted	1125	51.45
50	10′ 0″	5 Cast filled and bolted	920	43.05
50	12′ 0″	6 Cast filled and bolted	1105	48.70
50	15′ 0″	7 Cast filled and bolted	1240	53.15
60	10′ 0″	5 Cast filled and bolted	1070	47.25
60	12′ 0″	6 Cast filled and bolted	1295	53.75
60	15′ 0″	7 Cast filled and bolted	1455	61.20

If switches of 25-lb. rails or over are provided with low target stand instead of ground throw, $3.00 extra per switch.

If provided with banner stand and high target, $6.00 extra.

Portable Tracks are used mainly for industrial purposes, especially in plantations, mines, handling lumber, quarries, wharves, power and industrial plants, but many times in general contractors' work the use of such track is economical because of its light weight, compactness, and portability. Portable track is usually shipped "knocked down" to save freight charges.

PORTABLE TRACK.

Gauge of Track, Inches,	—Weight of Rail— Pounds per Yard.	Kg. per Meter.	Weight per Foot of Track, Pounds.	Price per Foot Track Complete.
20	9	4.5	8.5	$0.315
21½	9	4.5	8.5	0.315
24	9	4.5	9	0.315
20	12	6	11	0.371
21½	12	6	11	0.371
24	12	6	11.50	0.371
30	12	6	12	0.420
36	12	6	14	0.476
20	16	8	15	0.476
21½	16	8	15	0.476
24	16	8	15.50	0.476
30	16	8	16	0.515
36	16	8	17	0.581
21½	20	10	17.5	0.515
24	20	10	18	0.515
30	20	10	19	0.581
36	20	10	20	0.630

The above prices, etc., are for track in sections of 15′ (or 5 m.) with 5 ties.

Section of 7′ 6″ (or 2.5 m.) length, $0.15 extra per foot, with 3 ties.

Curved section, $0.25 extra per foot.

Note.—All material for 21½″ gauge of track for outside flanged wheels.

TABLE 144—PORTABLE SWITCHES.

Gauge of Track, Inches.	Weight of Rail, Pounds per Yard.	Description.	Length, Feet.	Radius, Feet.	Wt., Pounds.	Price.
20	9	Right	9	12	200	$16.80
20	9	Left	9	12	200	16.80
24	9	Right	9	12	205	16.80
24	9	Left	9	12	205	16.80
20	12	Right	9	12	250	18.90
20	12	Left	9	12	250	18.90
20	12	Symmetric	9	12	240	21.00
20	12	3 way	9	12	370	47.25
24	12	Right	9	12	255	18.90
24	12	Left	9	12	255	18.90
24	12	Symmetric	9	12	245	21.00
24	12	3 way	9	12	375	47.25
24	12	Right	15	30	350	26.25
24	12	Left	15	30	350	26.25
24	12	Symmetric	15	30	535	28.35
24	12	3 way	15	30	600	63.00
20	16	Right	9	12	345	21.00

TABLE 144—PORTABLE SWITCHES—(Continued).

Gauge of Track, Inches.	Weight of Rail, Pounds per Yard.	Description.	Length, Feet.	Radius, Feet.	Wt., Pounds.	Price.
20	16	Left	9	12	345	$21.00
20	16	Symmetric	9	12	330	23.10
20	16	3 way	9	12	510	52.50
24	16	Right	9	12	350	21.00
24	16	Left	9	12	350	21.00
24	16	Symmetric	9	12	335	23.10
24	16	3 way	9	12	515	52.50
24	16	Right	15	30	430	31.50
24	16	Left	15	30	430	31.50
24	16	Symmetric	15	30	420	33.60
24	16	3 way	15	30	675	73.50
24	20	Right	9	12	410	23.10
24	20	Left	9	12	410	23.10
24	20	Symmetric	9	12	395	26.25
24	20	Right	15	30	550	34.65
24	20	Left	15	30	550	34.65
24	20	Symmetric	15	30	520	37.80
21½	12	Right	8	12	225	21.00
21½	12	Left	8	12	225	21.00
21½	12	Symmetric	8	12	220	23.10
21½	12	3 way	8	12	350	50.40
21½	16	Right	8	12	310	23.10
21½	16	Left	8	12	310	23.10
21½	16	Symmetric	8	12	300	25.20
21½	16	3 way	8	12	460	54.60

Note.—All material for 21½" gauge of track is for outside flanged wheels.

TURNTABLES.

Turntables for industrial cars using rail weighing up to about 20 lbs. per yard, cost from $25.00 to $175.00 and weigh from 300 to 3,000 lbs. Their capacity ranges from 2 to 7 tons.

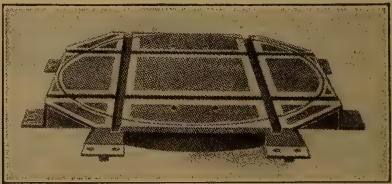


Fig. 242a. Standard Ball-Bearing Turntable.

DEPRECIATION.

Rails in general lose value from the following causes:

1. Through loss of weight due to corrosion.
2. From becoming bent and unfit for smooth operation.
3. From the weakening effect of attrition or wear.

The first of these causes depends partly upon the climatic conditions and partly upon the nature of the traffic that goes over the rails. Refrigerator cars containing a large amount of

brine are very deadly to steel rails because the brine leaking slowly upon the rail tends to keep it more or less saturated with a salt solution which rapidly combines with the iron to form hydrated iron oxide or rust.

The second cause outlined above obtains principally on contractors' light rail, where the rail is too light for the track and where the ties are spaced too far apart. If contractors would appreciate the fact that a rail which has been thoroughly kinked is fit only for scrap and that it need not be kinked at all if the ties are properly spaced, their depreciation on ordinary equipment of this kind would be much less than it usually averages, and there would be the collateral advantage of fewer derailments. Today the habit is growing among contractors to use a rail of heavier section than formerly, and also to space the ties nearer together. These ties should never be more than three ft. apart and seldom more than 30 in. A good weight of rail for narrow gauge track is 40 lbs.

Mr. Thos. Andrews has published the results of some examinations of the loss of weight per annum of 11 rails of known age and condition under mail train traffic in England. The first ten of these were in the open and the eleventh, with a life of 7 years, was in a tunnel. The average wear and life of each are given in the following table:

Time Life.	Average Loss of Wt. per Annum, Pounds per Yard.
22 years	.260
24 years	0.310
23 years	0.130
23 years	0.130
21 years	0.480
25 years	0.420
17 years	0.320
18 years	0.280
18 years	0.280
19 years	0.630
21 years, average (10)	0.324
7 years	2.800

Cost of Rail Unloading. Mr. S. A. Wallace gives the following costs for unloading 70-lb., 33-ft. rail by dropping it off the sides of cars. The cars unloaded were 3 Gondola cars containing 281 rails, and 1 flat car containing 113 rails, a total of 394 rails. The time consumed was 3 hours and the cost as follows:

18 men at $1.10 per day	$ 7.59
3 foremen at $50.00 per month	1.84
Work train	25.00
Total	$34.43

This gives a cost of 8.7 cts. per rail, or $27.84 per mile of track.

Under favorable circumstances ninety 85-lb. rails were unloaded from a flat car in 45 minutes at the following cost:

Train service	$ 1.56
Labor	1.05
Total for 90 rails	$ 2.61

This gives a cost of 2.9 cts. per rail, or of $9.30 per mile of track.

Contractors' light track of 30-lb. rail with 36-in. gauge was laid on a grading job in 1909. Teams and drivers cost 55 cts.; labor, 15 cts., and foreman, 35 cts. per hour. The rail and ties, which latter were of 6x6-in. spruce, 5 ft. long, were gathered from various places on the work and hauled by horses an average distance of 1,500 ft. to the site of the track; 1,000 ft. of track, including 2 complete switches, with ties 4 ft. apart, were laid, at a total labor cost of $56.65, or $0.057 per ft.

1,500 lin. ft. of track, including two switches, similar to above, were laid on another job in five days at the following cost:

1 foreman	at	$3.50	$ 17.50
8 men	at	1.50	60.00
1 man	at	2.00	10.00
1 man	at	1.75	8.75
1 team	at	5.00	25.00
			$121.25=$0.081/ft.

The labor cost of unloading and setting up industrial track in buildings under construction is about 3 cts. per lin. ft. of track. It costs about the same to move such track from floor to floor and set up again.

PARTICULARS REQUIRED FOR INQUIRIES AND ORDERS.

In order to facilitate the making up of offers and estimates and to save time and unnecessary correspondence, buyers should always answer the following questions as completely as possible:

For Rails. State weight per yard, name of mill rolling the rail and number of section (both of which can be found on web of rail), or send sketch of section or a short sample piece. Also state drilling of same; distance from end of rail to center of first hole and distance from center of first hole to center of second hole, and diameter of holes.

For Switches. Besides the foregoing, state gauge of track, length of switch points, number or angle of frog, style of frog, kind of groundthrow or switchstand, radius desired, whether right, left, two-way or three-way, and whether for wooden ties or mounted on steel ties.

For Crossings. Besides rail section, drilling and gauge, as above, for *all tracks,* that are to be connected by the crossing, state angle of crossing, curvature, if any, and style of crossing.

For Turntables. Besides rail section, drilling and gauge, as above, state weight of car, including load to be turned, its wheelbase (wheelbase is the distance from center to center of axle on one side of the car), diameter of wheels, and whether turntable is to be used inside or outside of buildings, and portable or permanent.

For Wheels and Axles. State gauge of track, diameter of wheels, diameter of axles, outside or inside journal and dimensions, load per axle, width of tread, height of flange.

RAIL BENDERS AND TRACK TOOLS.

Jim Crow Benders cost as follows:

No.	For Rail, Lbs.	Weight, Lbs.	Price.
1	100	225	$17.00
2	75	178	15.00
3	56	87	11.25
4	30	63	9.25
5	20	48	7.75

Roller Rail Benders cost as follows:

No.	For Rail, Lbs.	Weight, Lbs.	Price.
3	61 to 70	400	$ 70.00
4	71 to 80	470	90.00
5	81 to 90	520	115.00
6	91 to 100	830	200.00

Track Tools—Net prices at Chicago for track tools are as follows:

	Per Lb.
Mauls, 6, 8, 10 and 12 lbs.	$0.05½
Chisels, 4½, 4¾ and 5 lbs.	.12
Punches, 4, 4½ and 5 lbs.	.12
Railroad track tongs, 17 lbs., pair	.07½
Rail forks, each 15 lbs.	.07

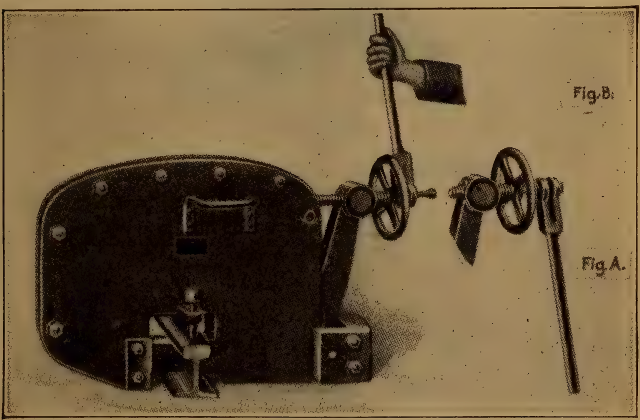


Fig. 243.

RAIL PUNCHES.

Capacity (Inches)	Holes Up to (Inches)	Weight (Pounds)	Price.
½	¾	250	$ 90.00
¾	1	350	131.65
1	1¼	500	169.00

Extra dies and punches, $4.00 to $8.00.

RAIL DRILLS.

Weight, 65 lbs. Price $30.00.

Guard Rails. The cost of a 15-ft. guard rail with the proper rail braces, new, is about as follows:

	Pounds per Yard									
	100 Pounds.	90 Pounds.	80 Pounds.	70 Pounds.	60 Pounds.	50 Pounds.	40 Pounds.	30 Pounds.	20 Pounds.	16 Pounds.
Price,	$10.30	$9.30	$8.30	$7.30	$6.30	$5.30	$4.80	$3.80	$2.80	$2.30
Weight,	450	410	370	330	290	240	200	150	100	80

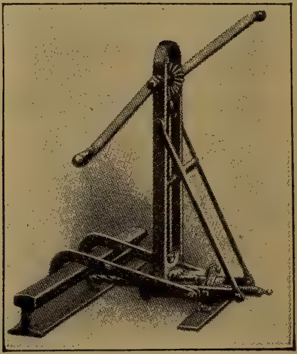


Fig. 244.

SPRING RAIL FROGS, 15′ LONG.

	Pounds per Yard						
	100 Pounds.	90 Pounds.	80 Pounds.	70 Pounds.	60 Pounds.	50 Pounds.	40 Pounds.
Price,	$51.00	$47.50	$44.50	$41.00	$38.00	$35.50	....
Weight,	1600	1450	1300	1170	1060	950	....

FROGS, 8′, WITH 5′ PLATE.

	Pounds per Yard								
	60 Pounds.	50 Pounds.	45 Pounds.	40 Pounds.	35 Pounds.	30 Pounds.	25 Pounds.	20 Pounds.	16 Pounds.
Price,	$24.00	$22.00	$20.50	$19.50	$18.50	$17.50	$16.50	$14.50	$13.50
Wt.,	640	570	500	460	415	375	330	260	230

For additional length of frog add per foot of frog:

90c	75c	65c	50c	45c	33c	30c

SWITCHES, STANDARD GAUGE, 4′ 8½″.

15′ Switch, 4 Tie Bars, 10 C. I. Braces, 10 Slides.

	Pounds per Yard									
	100 Pounds.	90 Pounds.	80 Pounds.	70 Pounds.	60 Pounds.	50 Pounds.				
Price,	$43.00	$40.00	$38.00	$34.50	$33.00	$31.00	....	....	....	....
Wt.,	1300	1200	1075	975	850	725	....	....	....	....

RAKES

Two-Man Rakes. Two-man rakes, used in leveling broken stone, sell at the following net prices, for quantities, at Chicago:

	Per Doz.
10-tooth	$21.25
12-tooth	23.75
14-tooth	26.25

Asphalt or Tar Rakes. Asphalt or tar rakes made of solid steel, with drop shank, strap ferrules, 5-ft. selected white ash handles and 18-in. square iron shanks, sell at a net price, for quantities, at Chicago, of $12.85 per doz.

REFRIGERATING PLANT

On large jobs where a camp of considerable size is maintained a refrigerating plant would often be very satisfactory. A 3-h. p. motor and air compressor with a direct expansion system and brine tank auxiliary for storage will take care of a box 9x6x11 ft., containing 1½ tons of perishable foods. The first cost of such an equipment would be about $1,000.00 and the operating cost of electricity about $20.00 per month.

RIVETING GUNS

TABLE 145—DESCRIPTION AND PRICES OF RIVETING GUNS.

Size No.	Weight, Pounds.	Cubic Feet Free Air per Minute at 80 Pounds Pressure.	Piston Stroke, Inches.	Length Over All, Inches.	Style—Long Stroke Riveting Hammers Suitable for	Equipment.	Price.
40	15	19½	4	16	No. 40 driving rivets, ½" diameter and less	Riveting hammers.......	$40.00
50	16½	18½	5	17½	No. 50 driving rivets, ¾" diameter and less	1 hose nipple, 1 strainer..	40.00
66	20	30	6	17½	No. 66 driving rivets, ⅞" diameter and less	1 wrench, 3 rivet sets, blank or finished.......	45 00
99	23	30½	9	20¾	No. 99 driving rivets, 1¼" diameter and less	1 rivet set clip or spring..	45.00

On Pierson & Son's work on the East River tunnels for the Pennsylvania Railroad 200,000 rivets were required in each of 2 caissons. The record day's work on the caisson was 1,496 rivets by a gang with a Boyer riveter working from a regularly

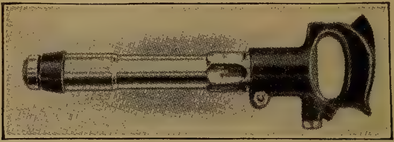


Fig. 245. Imperial Type E Riveting Hammer. For Driving Rivets up to ¾-inch Diameter.

suspended scaffold. One extra man worked in the gang. 1,200 rivets were the ordinary day's work. All rivets had to be tightly driven so as to render work absolutely water tight.

Steel Rivets.* The following prices for steel rivets were f. o. b. Pittsburgh and were minimum on contracts for large lots; the

Fig. 246. Riveting Hammer at Work.

manufacturers charged the usual advances of $2.00 to $3.00 per ton to the small trade. The terms were net cash f. o. b. mill:

Structural rivets, ¾-in. and larger, 2.15 cts. base.

Steel Rivets.† The following prices for steel rivets were f. o. b. mill at Pittsburgh:

Structural rivets, ¾-in. and larger, 1.90 cts. base; cone head boiler rivets, ¾-in. and larger, 2 cts. base; ⅝-in. and $\frac{11}{16}$-in. take an advance of 15 cts., and ½-in. and $\frac{9}{16}$-in. take an advance of 50 cts.; lengths shorter than 1-in. also take an advance of 50 cts.

* *Engineering-Contracting*, Apr. 6, 1910.
† *Engineering-Contracting*, Apr. 5, 1911.

ROAD MACHINES

(See Grading Machines)

ROAD CONSTRUCTION PLANT OF THE BOARD OF ROAD COMMISSIONERS OF WAYNE COUNTY, MICHIGAN.

(From *Engineering-Contracting,* Nov. 9, 1910.)

Some years ago Wayne County, Michigan, adopted a plan for the construction of good roads throughout the county. In accordance with this plan a board of county road commissioners, reporting to the county supervisors, was appointed to handle and disburse all money appropriated for county road purposes. A definite systematic plan of road construction covering a period of years was adopted, and work under this plan has now been under way for four years. The work of the commissioners is extensive, covering, as it does, the main highways leading into the city of Detroit and the main highways radiating from the smaller communities in the county. One feature of especial interest in the work of the commissioners is the comparatively large mileage of concrete paved roads that have been constructed. Of this type of road about 15 miles have been completed or are under way at the present time. Most of the road work has been done by day labor, at times as many as 250 men being in the employ of the commission.

In its road work the board has eliminated all hand and horse labor wherever the same or better results could be achieved by machinery. Stone, cement and sand are hauled in trains of from two to six cars holding seven ton loads by road engines. Water is piped and pumped by gasoline engines wherever possible. Plowing and grading are done behind an engine. Concrete is mixed in a mechanical batch mixer which travels under its own power and from which a long crane projects over the work, on which a clamshell bucket travels with the mixed material. The accompanying figures taken from the fourth annual report of the road commissioners for the year ending Sept. 30, 1910, show the original cost of the plant used by the commissioners in their road work:

Hauling and Grading Machinery and Equipment:		
Steam engines	2	$ 4,870.00
Road rollers	4	9,607.00
Seven-ton Stone dump wagons	24	6,780.00
Top boxes for same	24	432.00
Tongues for same	1	16.00
Sprinkling wagons	12	2,229.00
Team dump wagons	4	440.00
Graders	2	425.00
Scarifier	1	424.79
Plows	3	61.75
Tool wagons	4	190.00
Tool boxes	2	8.50
Scrapers, Doan	3	15.00
Scrapers, steel	2	9.50
Scrapers, hand	1	1.00
Scrapers, wheeled	4	100.00
		$25,609.54

Concrete Equipment:

Concrete mixers	2	$ 3,475.00
Platform for same	1	23.15
Concrete carts	6	114.00
Wheelbarrows	37	130.27
Road forms	7	45.90
Road irons, 25 feet long	3	17.50
Trowels	2	1.50
Galvanized cylinder	1	2.50
Floats, steel	1	.95
Wire screens	1	1.50
Name plates	2	27.50
2-in. black lead pipe, feet, 5,367	..	302.17
Canvases for protecting concrete	24	433.93
Tarpaulins, 20x30	2	78.00
Tarpaulins, 12x15	2	23.40
Water tanks, stationary	2	15.00
Hydrant reducer	1	4.75
Special goose-neck reducer	1	1.20
Hose	..	15.00
Tampers, various sizes	9	6.75
Iron pins	48	12.00
T-squares (grading bars)	9	9.00
		$ 4,740.97

Maintenance Equipment:

Street sweeper (and extra broom)	1	$ 238.00
Road drag	1	15.63
Scythe and snath	3	5.25
Tar kettles, 100 gallons	2	220.00
Wire and splint brooms	14	8.40
Sprinkling cans	14	14.00
Barrel spouts	15	.90
		$ 502.18

Blacksmithing Outfit and Tools:

Post drill	1	$ 10.50
Ratchet drill	1	6.75
Breast drill	1	3.75
Drill bits	set	4.15
Anvil	1	16.80
Forge	1	10.80
Tongs, pairs	2	4.60
Reamer	1	.50
Hacksaw	1	1.00
		$ 58.85

Shovels and Handled Tools:

Shovels, L. H.	87	$ 63.53
Shovels, D. H.	67	48.40
Shovels, scoop	7	5.25
Spades, garden	7	4.88
Spades, tiling	20	18.90
Stone forks	17	30.69
Picks	47	30.75
Grub hoes	2	1.00
Mattocks	14	11.20
Stone rakes	5	3.75
Post hole digger	1	1.50
Hoes	3	2.75
Crowbars	4	2.40
		$ 225.00

Concrete Tile Making Equipment:

Molds, 8-in.	5	$ 87.50
Molds, 12-in.	7	153.50
Top rings, 8-in.	5	4.00
Top rings, 12-in.	3	2.85
Bottom rings, 8-in.	36	18.00
Bottom rings, 12-in.	72	46.90
Irons for bending reinforcement	1	2.00
Pallets	200	27.12
		$ 341.87

Camp Equipment:

Mess and bunk tents	2	$ 104.86
Outhouse tents	2	3.92
Tent cover, 20x30, with poles	1	42.14
Canvas fences	2	7.35
Cots	18	16.02
Pads for cots	15	18.75
Comforters	18	17.64
Pillows	18	8.82
Pillow-cases	18	2.25
B blankets	18	28.62
G blankets	18	10.62
Towels	12	1.25
Dishes, cutlery, pots, kettles, cooking utensils and other camp equipment	..	98.93
		$ 361.17

In addition to the above the commissioners own the following:

	Cost.
Carpenters' tools	$ 32.73
Miscellaneous	131.96
Engineering and office equipment	1,025.97
Cement testing apparatus	55.05

The total original cost of the plant and property was $33,185.38. The depreciation for 1909 was placed at $3,850.88 and the depreciation for 1910 at 15 per cent was placed at $4,400.18.

ROAD-MAKING PLANT.

The following is the approximate cost of a road-making plant, operating in the State of Missouri:

Six dump cars and 200 ft. of trackage for use in quarry	$ 600.00
Crusher, 11 in. by 18 in., 25 tons per hour capacity	775.00
Bin—3 sections	350.00
Elevator—14 ft.	150.00
Revolving screen—30 in., 4 ft. long	125.00
Two traction engines—20 h. p.	3,000.00
One 10-ton steam roller—15 h. p.	2,500.00
One 6-horse grader	200.00
Six dump wagons—1½ cu. yds.	600.00
Twelve hand drills, 12 picks, 12 crowbars, 24 shovels	50.00
One road plow, $5—11 in. cut, 4 horse	20.00
Six wheelers, No. 2—12 cu. ft. capacity	200.00
Six drags, No. 2—4½ cu. ft. capacity	40.00
Sprinkling wagon, No. 3—600 gals. capacity	325.00
	$8,935.00

Moving the plant 12 miles overland and setting it up at a new quarry cost $500. After the move, the plant, new to begin with, which had only been used to build four miles of 16-ft. roadbed, cost $200 for new fittings and repairs, which, for six months' use, is an annual depreciation on plant of 5 per cent of the cost.

ROOFING SLATE

Market Price. Quotations are named per "square," or 100 sq. ft. of roof surface, in carload lots of the sizes most generally used, f. o. b. quarry station:

	Per 100 Sq. Ft.
Vermont, sea green	$ 3.50 to $4.10
Pennsylvania, Bangor Ribbon	3.50 to 4.00
Maine, Brownsville No. 1	5.00 to 7.75
Maine, Brownsville No. 2	4.50 to 6.00
No. 1 red	10.50 to 12.00
Unfading green	4.00 to 5.50
Genuine Bangor	4.00 to 6.50
Pen Argyle	4.00 to 5.50

ROLLERS

A reversible horse roller of the latest type, with two rolls having a total face width of 5 ft., is manufactured in sizes from 3½ to 10 tons of ½-ton variation and is sold for $70.00 per ton. The diameter of the rolls varies from 4½ ft. on the lightest rollers to 6 ft. on the heaviest.

A steel reversible horse road roller having two rolls of a total width of 5 ft. comes in the following sizes and prices:

3½-ton	$230.00
4-ton	260.00
4½-ton	290.00
5-ton	325.00
5½-ton	355.00

or about $65.00 per ton.

Horse Lawn Rollers in 3 to 5 sections, weighing 500 to 1,500 lbs., cost 3¾ cts. per lb.

HAND ROLLERS

Diameter (Ins.)	Length (Ins.)	Sections (Ins.)	Weight (Lbs.)	Price
15	24	3	200	$ 8.00
20	24	3	300	12.00
20	24	2	300	12.00
24	24	2	450	17.75
24	24	3	450	17.75

Rollers 50 to 300 lbs. heavier than any of the above, 4 cts. per lb. extra.

HORSE ROLLERS

No.	Diameter (Ins.)	Length (Ft.)	No. Sections	Face (Ins.)	Weight (Lbs.)	Price Each
80	36	4	4	12	3,000	$141
81	36	5	5	12	3,500	161
82	36	6	6	12	4,000	180
83	48	3¾	3	15	4,000	186
84	48	5	4	15	5,000	228
85	48	6¼	5	15	6,000	270
86	54	3¾	3	15	6,000	276
87	54	5	4	15	8,000	363
88	54	6¼	5	15	10,000	450

A standard steam-driven road roller with a double cylinder engine, having two speeds, which can be thrown out of gear and used for motor power (for which purpose a set of extra driving attachments are necessary), is made in three sizes. It has a differential gear and a hand wheel steering device, and is constructed entirely of steel, with the exception of wheels and engine bed, which are of cast iron.

Weight	10 Tons	12 Tons	15 Tons
Price	$2,500	$2,650	$2,850

Another standard steam roller of improved type whose points of superiority lie in the extra large steam dome, the fly wheel

and crank shaft mounted so as not to obstruct the view, differential gear, two speeds, and a very accessible boiler, also has a

Fig. 247. Cast Iron Reversible Road Roller.

sloping crown sheet which assists in keeping this part covered with water when working head-on down hill.

Weight	10 Tons	12 Tons	15 Tons
Price	$2,400	$2,800	$3,300

A 10-ton steam road roller which is convertible into a traction engine has the following advantages: a short wheel base allowing

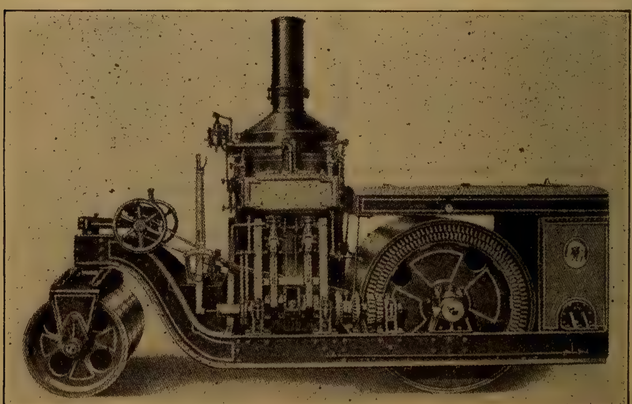


Fig. 248. Iroquois 5-Ton Tandem.

short turnings, a spring differential gear, a friction clutch for gradual application of power, a steam-operated friction steering mechanism, 8¼x10-in. cylinder. Simple engine, $2,000.00; compound engine, $2,100.00.

Extra traction engine wheels and equipment, $110.00.

Another 10-ton road roller convertible into a traction engine, which has a boiler of the return flue type and a friction steering device, costs $2,400.00. The front roll of this roller, when detached and fitted with a pole, which is included in the above price, can be used as a horse roller.

A 5-ton tandem roller (Fig. 248), with a vertical boiler and an engine of the double cylinder plain slide valve type, costs $1,600.00. Power steering device, $50.00 extra.

Cost of Maintenance and Operation of Steam Rollers. The following table shows the cost of maintenance and operation of the six steam road rollers owned by the city of Grand Rapids, Mich. The figures have been taken from the annual report of the City Engineer for the fiscal year ending March 31, 1911.

COST OF MAINTENANCE AND OPERATION OF STEAM ROAD ROLLERS

Maintenance:	No. 1 Roller	No. 2 Roller	No. 3 Roller	No. 4 Roller	No. 5 Roller	No. 6 Roller
Labor, shop	$ 117.37	$ 106.72	$ 149.67	$ 116.67	$ 25.11	$ 99.61
Repair parts	332.94	126.46	224.16	128.12	63.57	43.19
Telephone	2.00	1.40	1.15	1.30	1.00	1.05
Engineering	2.00	6.00	3.00	2.00	2.00	3.00
Carfare	.25	.60	.15	.20	.20	.15
Belting	3.18	....	1.14	.84	1.82	1.27
Wagon repair	4.25	4.70	....	.40	......	6.50
Chains and hooks	3.36	....	....	....	......	3.37
Telegrams	.49	....	....	....	......	.64
Paint	.75	1.35	....	....	......	....
Express	.15	.25	....	....	......	....
Hose	....	5.87	....	....	......	....
Roller repair	....	27.18	11.50	....	......	....
New wheels	....	197.10	....	....	......	....
Oilers	....	1.60	....	....	2.70	....
Canvas covers	....	....	22.44	....	......	....
Rolling flues	....	....	7.90	4.50	1.60	....
Seat and spring	....	....	....	1.05	......	....
Hand hole clamps	....	....	....	.25	......	....
Padlocks and chains	....	....	....	....	.60	.75
Brackets	....	....	....	....	2.10	....
Total	$ 466.74	$ 479.23	$ 421.11	$ 255.33	$100.90	$ 159.53
Operation:						
Labor, running	$ 807.48	$ 822.40	$ 783.60	$ 835.05	$390.00	$ 831.30
Labor, cleaning	34.00	34.00	32.00	58.00	3.50	6.00
Tools	1.34	4.19	.26	1.40	2.08	1.85
Coal	347.32	356.17	316.73	215.01	178.46	278.86
Kindling	25.00	25.00	21.50	15.60	11.50	19.50
Oil	20.47	25.80	20.61	17.68	10.25	14.90
Waste	2.20	3.87	2.48	2.07	2.46	2.46
Cartage	4.73	7.18	3.64	.25	2.40	2.00
Packing	1.25	2.60	2.55	....	.75	....
Boiler compound	6.24	7.80	4.68	1.92	......	3.90
Matches	.13	.05	.04	....	......	....
Lanterns and globes	1.26	.80	....	2.23	1.90	1.26
Grease	....	.37	.72	.11	......	.18
Candles	....	.06	.06	.06	......	.27
Total Op. and Maint.	$1,718.16	$1,769.52	$1,609.98	$1,404.71	$704.00	$1,322.01
Total Operation	$1,251.42	$1,290.29	$1,188.87	$1,149.38	$603.10	$1,162.48

Repairs on two rollers of the convertible type during the first season of operation cost $86.00; $77.00 of this was for one roller which had not been kept in good shape and $9.00 was for the other roller, which was operated by a particularly efficient engineer.

In 1905, on 16 steam rollers belonging to the Massachusetts Highway Commissioners, each roller averaged 90.3 working days per year and the average cost of repairs was $1.12 per day per roller.

In 1906 the total days' work of 16 rollers under the control of the Massachusetts Highway Commission was 1,719.5, an average of 107.5 days per roller per season. Total cost for maintenance of these rollers was as follows:

$1,725.00 for practically rebuilding two rollers which had been in active service about ten years, and an average of $53.14 each on 14 others. The total cost of repairs on 16 rollers was, therefore, $2,468.96, or an average of $154.31 each.

In 1907 the above 16 rollers did 1,808 days' work, an average of 113 days per roller per season. Two rollers were practically rebuilt for $1,888.00 and ordinary repairs on the 14 others cost $651.69. The total average cost was, therefore, $158.73.

Mr. Thomas Aitken, the English author, states that the repairs

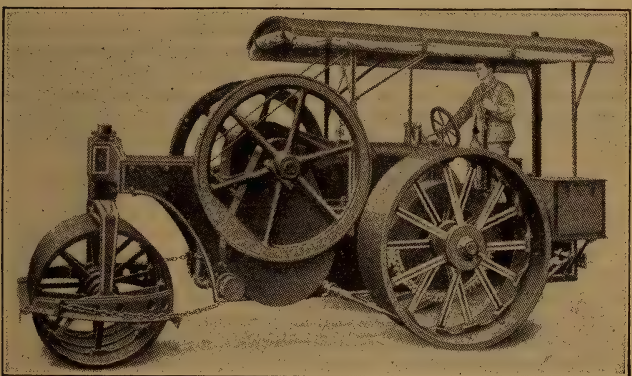


Fig. 249. American Motor Road Roller (Left Side View).

on a roller up to the 14th year were small, with the exception of new driving wheels and repairs to the firebox and tubes. All repairs amounted to an average of $55.00 a year. At this time heavy repairs, costing $850.00, were needed. The total cost per year during a life of 25 years, of 100 working days each, is $105.00, or 5% of the first cost. The rear wheels of a roller lasted 7 years, during which time they consolidated 60,000 tons of road metal.

A motor road roller of the 3-wheeled type (Fig. 249), operated by gasoline or denatured alcohol, is made in five sizes at the following prices:

Size.	Price f. o. b. Factory
7-ton	$2,250
8-ton	2,300
10-ton	2,500
12-ton	2,650
15-ton	3,000

The 10-ton or larger sizes will haul a scarifier, grader or road plow.

This machine has a trussed frame made of heavy steel plates, which carries the engine, thereby eliminating a great defect found in steam rollers, that of making the boiler act as the frame.

Some of the advantages over the steam roller claimed for this machine by the manufacturers are:

1. No smoke, steam, sparks or soot blowing about.
2. No daily water supply needed.
3. No daily coal supply needed.
4. No nightly banking of fires.
5. No time lost raising steam.
6. Licensed engineer not necessary.
7. No laying up for boiler repairs.

The great disadvantage is the unreliability of all gasoline engines. However, in situations where coal transportation is expensive, a motor roller is the proper machine to use, as it has a tank capacity for 10 to 20 hours' fuel, and can trail a tank wagon carrying a month's supply.

ROPE

Wire Rope. The first wire ropes were constructed largely of iron wire, but the modern wire rope is made of variously manipulated and treated carbon steels. The usual classifications are:

Iron.
Crucible steel.
Extra strong crucible steel.
Plow steel.

The so-called Iron is a mild Bessemer or Basic steel of from 60,000 to 100,000 lbs. per square inch tensile strength; the Crucible Steel is a carbon open hearth steel of from 160,000 to 200,000 lbs. per square inch tensile strength; the Extra Strong Crucible Steel ranges in strength from 200,000 to 240,000 lbs. per square inch, and the Plow Steel ranges from about 240,000 lbs. per square inch up.

Up to May 1, 1909, the breaking strengths of wire rope manufactured in the United States were based upon the strength of the individual wires in the rope, but since that time all manufacturers have adopted strength figures compiled from results of actual tests.

There are a vast number of arrangements possible in wire rope construction, but the usual construction is one in which a number of wires are built up on a hemp core.

Discounts. The standard discounts, Dec., 1913, were 47% and 2½% from list for galvanized, and 55% and 2½% for the bright.

TRANSMISSION, HAULAGE OR STANDING ROPE.

Fig. 250. 6 Strands — 7 Wires to the Strand—One Hemp Core.

Six strands of seven wires each built on a hemp core make what is known as haulage rope. This is one of the oldest types and was formerly largely used for power transmission, but now its use is largely confined to mines, for slope haulage systems embodying endless and tail rope applications, on coal docks, in oil well drillings, and, when galvanized, as guys for derricks. It will stand considerable abrasion and rough handling, but is stiff, and its use, therefore, is limited.

PRICES TRANSMISSION, HAULAGE OR STANDING ROPE.

(Standard Strengths, Adopted May 1, 1910)

6-Strands—7 Wires to the Strand—One Hemp Core

SWEDES IRON

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Wt. per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
11	$0.51	1½	4¾	3.55	32	6.4	16
12	.43	1⅜	4¼	3	28	5.6	15
13	.36	1¼	4	2.45	23	4.6	13
14	.30	1⅛	3½	2	19	3.8	12
15	.24	1	3	1.58	15	3	10.5
16	.18½	⅞	2¾	1.20	12	2.4	9
17	.14	¾	2¼	.89	8.8	1.7	7.5
18	.12	11/16	2⅛	.75	7.3	1.5	7.25
19	.10	⅝	2	.62	6	1.2	7
20	.08¼	9/16	1¾	.50	4.8	.96	6
21	.06½	½	1½	.39	3.7	.74	5.5
22	.05½	7/16	1¼	.30	2.6	.52	4.5
23	.04½	⅜	1⅛	.22	2.2	.44	4
24	.03¾	5/16	1	.15	1.7	.34	3.5
25	.03¼	9/32	⅞	.12½	1.2	.24	3

CRUCIBLE CAST STEEL

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Wt. per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
11	$0.60	1½	4¾	3.55	63	12.6	11
12	.51	1⅜	4¼	3	53	10.6	10
13	.43	1¼	4	2.45	46	9.2	9
14	.36	1⅛	3½	2	37	7.4	8
15	.29	1	3	1.58	31	6.2	7
16	.22½	⅞	2¾	1.20	24	4.8	6
17	.17	¾	2¼	.89	18.6	3.7	5
18	.14½	11/16	2⅛	.75	15.4	3.1	4¾
19	.12	⅝	2	.62	13	2.6	4½
20	.10	9/16	1¾	.50	10	2	4
21	.08	½	1½	.39	7.7	1.5	3½
22	.06½	7/16	1¼	.30	5.5	1.1	3
23	.05½	⅜	1⅛	.22	4.6	.92	2¾
24	.04½	5/16	1	.15	3.5	.70	2¼
25	.04	9/32	⅞	.12½	2.5	.50	1¾

EXTRA STRONG CRUCIBLE CAST STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Wt. per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
11	$0.75	1½	4¾	3.55	73	14.6	11
12	.64	1⅜	4¼	3	63	12.6	10
13	.53	1¼	4	2.45	54	10.8	9
14	.44	1⅛	3½	2	43	8.6	8
15	.35	1	3	1.58	35	7	7
16	.27	⅞	2¾	1.20	28	5.6	6
17	.20	¾	2¼	.89	21	4.2	5
18	.17	11/16	2⅛	.75	16.7	3.3	4¾
19	.14¼	⅝	2	.62	14.5	2.9	4½
20	.12	9/16	1¾	.50	11	2.2	4
21	.09½	½	1½	.39	8.85	1.8	3½
22	.07½	7/16	1¼	.30	6.25	1.25	3
23	.06	⅜	1⅛	.22	5.25	1.05	2¾
24	.05½	5/16	1	.15	3.95	.79	2¼
25	.05	9/32	⅞	.12½	2.95	.59	1¾

PLOW STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised
11	$0.90	1½	4¾	3.55	82	16.4	11
12	.76	1⅜	4¼	3	72	14.4	10
13	.62	1¼	4	2.45	60	12	9
14	.51	1⅛	3½	2	47	9.4	8
15	.41	1	3	1.58	38	7.6	7
16	.32	⅞	2¾	1.20	31	6.2	6
17	.24½	¾	2¼	.89	23	4.6	5
18	.21	11/16	2⅛	.75	18	3.6	4¾
19	.17½	⅝	2	.62	16	3.2	4½
20	.14½	9/16	1¾	.50	12	2.4	4
21	.11½	½	1½	.39	10	2	3½
22	.09	7/16	1¼	.30	7	1.4	3
23	.06¾	⅜	1⅛	.22	5.9	1.2	2¾
24	.06	5/16	1	.15	4.4	.88	2¼
25	.05½	9/32	⅞	.12½	3.4	.68	1¾

MONITOR PLOW STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised
11	$1.05	1½	4¾	3.55	90	18	11
12	.88	1⅜	4¼	3	79	16	10
13	.72	1¼	4	2.45	67	13	9
14	.58	1⅛	3½	2	52	10	8
15	.48	1	3	1.58	42	8.4	7
16	.37	⅞	2¾	1.20	33	6.6	6
17	.28½	¾	2¼	.89	25	5	5
18	.24½	11/16	2⅛	.75	20	4	4¾
19	.20½	⅝	2	.62	17½	3.5	4½
20	.17	9/16	1¾	.50	13	2.6	4
21	.13½	½	1½	.39	11	2.2	3½
22	.11½	7/16	1¼	.30	7¾	1.5	3
23	.08¾	⅜	1⅛	.22	6½	1.3	2½

All ropes not listed herein and composed of more than 7 and less than 19 wires to the strand, with the exception of 6x8, take 19 wire list.

Add 10 per cent to list prices for wire center or galvanized rope.

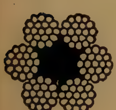


Fig. 251. 6 Strands — 19 Wires to the Strand — One Hemp Core.

STANDARD HOISTING ROPE.

Six strands of nineteen wires each make a hoisting rope which has a wider and more varied application than any other type. It combines both flexibility and wearing service and is used in mining shafts, for operating the cages and elevators, derricks, coal and ore handling machines, logging, dredges, skip hoists, conveyors, etc.

PRICES STANDARD HOISTING ROPE.

(Standard Strengths, Adopted May 1, 1910)

6 Strands—19 Wires to the Strand—One Hemp Core

SWEDES IRON

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
00	$1.70	2¾	8⅝	11.95	111	22.2	17
0	1.40	2½	7⅞	9.85	92	18.4	15
1	1.17	2¼	7⅛	8	72	14.4	14
2	.95	2	6¼	6.30	55	11	12
2½	.83	1⅞	5¾	5.55	50	10	12
3	.80	1¾	5½	4.85	44	8.8	11
4	.65	1⅝	5	4.15	38	7.6	10
5	.57	1½	4¾	3.55	33	6.6	9
5½	.49	1⅜	4¼	3	28	5.6	8.5
6	.40	1¼	4	2.45	22.8	4.56	7.5
7	.33	1⅛	3½	2	18.6	3.72	7
8	.26	1	3	1.58	14.5	2.90	6
9	.20	⅞	2¾	1.20	11.8	2.36	5.5
10	.16	¾	2¼	.89	8.5	1.70	4.5
10¼	.12	⅝	2	.62	6	1.20	4
10½	.10	9/16	1¾	.50	4.7	.94	3.5
10¾	.08½	½	1½	.39	3.9	.78	3
10a	.07½	7/16	1¼	.30	2.9	.58	2.75
10b	.07	⅜	1⅛	.22	2.4	.48	2.25
10c	.06¾	5/16	1	.15	1.5	.30	2
10d	.06½	¼	¾	.10	1.1	.22	1.50

CRUCIBLE CAST STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
00	$2.10	2¾	8⅝	11.95	211	42.2	11
0	1.75	2½	7⅞	9.85	170	34	10
1	1.44	2¼	7⅛	8	133	26.6	9
2	1.16	2	6¼	6.30	106	21.2	8
2½	1.02	1⅞	5¾	5.55	96	19	8
3	.90	1¾	5½	4.85	85	17	7
4	.77	1⅝	5	4.15	72	14.4	6.5
5	.66	1½	4¾	3.55	64	12.8	6
5½	.56	1⅜	4¼	3	56	11.2	5.5
6	.46	1¼	4	2.45	47	9.4	5
7	.38	1⅛	3½	2	38	7.6	4.5
8	.31	1	3	1.58	30	6	4
9	.24	⅞	2¾	1.20	23	4.6	3.5
10	.19	¾	2¼	.89	17.5	3.5	3
10¼	.14	⅝	2	.62	12.5	2.5	2.5
10½	.12	9/16	1¾	.50	10	2	2.25
10¾	.11	½	1½	.39	8.4	1.68	2
10a	.10	7/16	1¼	.30	6.5	1.30	1.75
10b	.09½	⅜	1⅛	.22	4.8	.96	1.50
10c	.09¼	5/16	1	.15	3.1	.62	1.25
10d	.09	¼	¾	.10	2.2	.44	1

EXTRA STRONG CRUCIBLE CAST STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
00	$2.55	2¾	8⅝	11.95	243	48.6	11
0	2.10	2½	7⅞	9.85	200	40	10
1	1.70	2¼	7⅛	8	160	32	9
2	1.34	2	6¼	6.3	123	24.6	8
2½	1.25	1⅞	5¾	5.55	112	22.4	8
3	1.10	1¾	5½	4.85	99	19.8	7
4	.94	1⅝	5	4.15	83	16.6	6.5
5	.80	1½	4¾	3.55	73	14.6	6
5½	.68	1⅜	4¼	3	64	12.8	5.5
6	.56	1¼	4	2.45	53	10.6	5
7	.46	1⅛	3½	2	43	8.6	4.5
8	.37	1	3	1.58	34	6.80	4
9	.29	⅞	2¾	1.20	26	5.20	3.5
10	.22	¾	2¼	.89	20 2	4.04	3
10¼	.16½	⅝	2	.62	14	2.80	2.5
10½	.14	9/16	1¾	.50	11.2	2.24	2.25
10¾	.12½	½	1½	.39	9.2	1.84	2
10a	.11½	7/16	1¼	.30	7.25	1.45	1.75
10b	.11	⅜	1⅛	.22	5.30	1.06	1.50
10c	.10¾	5/16	1	.15	3.50	.70	1.25
10d	.10½	¼	¾	.10	2.43	.49	1

PLOW STEEL.

Trade Number	List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
00	$3.00	2¾	8⅝	11.95	275	55	11
0	2.50	2½	7⅞	9.85	229	46	10
1	2.00	2¼	7⅛	8	186	37	9
2	1.58	2	6¼	6.3	140	28	8
2½	1.46	1⅞	5¾	5.55	127	25	8
3	1.30	1¾	5½	4.85	112	22	7
4	1.08	1⅝	5	4.15	94	19	6.5
5	.93	1½	4¾	3.55	82	16	6
5½	.79	1⅜	4¼	3	72	14	5.5
6	.65	1¼	4	2.45	58	12	5
7	.54	1⅛	3½	2	47	9.4	4.5
8	.43	1	3	1.58	38	7.6	4
9	.34	⅞	2¾	1.20	29	5.8	3.5
10	.26	¾	2¼	.89	23	4.6	3
10¼	.19	⅝	2	.62	15.5	3.1	2.5
10½	.16	9/16	1¾	.50	12.3	2.4	2.25
10¾	.14	½	1½	.39	10	2	2
10a	.13	7/16	1¼	.30	8	1.6	1.75
10b	.12½	⅜	1⅛	.22	5.75	1.15	1.50
10c	.12¼	5/16	1	.15	3.8	.76	1.25
10d	.12	¼	¾	.10	2.65	.53	1

MONITOR PLOW STEEL

Trade No.	List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Feet Advised.
00	$3.45	2¾	8⅝	11.95	315	63	11
0	2.80	2½	7⅞	9.85	263	53	10
1	2.50	2¼	7⅛	8	210	42	9
2	1.85	2	6¼	6.30	166	33	8
2½	1.75	1⅞	5¾	5.55	150	30	8
3	1.60	1¾	5½	4.85	133	27	7
4	1.30	1⅝	5	4.15	110	22	6½
5	1.10	1½	4¾	3.55	98	20	6
5½	.90	1⅜	4¼	3	84	17	5½
6	.75	1¼	4	2.45	69	14	5
7	.62	1⅛	3½	2	56	11	4½
8	.50	1	3	1.58	45	9	4
9	.39	⅞	2¾	1.20	35	7	3½
10	.31	¾	2¼	.89	26.3	5.3	3
10¼	.22½	⅝	2	.62	19	3.8	2½
10½	.19	9/16	1¾	.50	14.5	2.9	2¼
10¾	.17	½	1½	.39	12.1	2.4	2
10a	.15½	7/16	1¼	.30	9.4	1.9	1¾
10b	.14½	⅜	1⅛	.22	6.75	1.35	1½
10c	.13½	5/16	1	.15	4.50	.9	1¼
10d	.13	¼	¾	.10	3.15	.63	1

All ropes not listed herein and composed of strands made up of more than 19 and less than 37 wires, take 37 wire list.

Add 10% to prices for wire center or galvanized rope.

"Where the requirements are severe, we recommend Monitor rope. It is the strongest and most efficient rope produced.

"It is indispensable for heavy dredging, logging, stump pulling, derricks, coal and ore hoisting service."

EXTRA FLEXIBLE STEEL HOISTING ROPE.

Eight strands of nineteen wires each make an extra flexible rope whose application is confined to a somewhat limited field. It is used on derricks and in similar places where sheaves are of very small diameter, and in flexibility is about on a par with the 6x37 construction, differing only in the fact that it is not quite as strong, owing to its large hemp center.

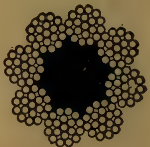


Fig. 252. 8 Strands — 19 Wires to the Strand — One Hemp Center.

LIST PRICES EXTRA FLEXIBLE STEEL HOISTING ROPE.

Standard Strengths Adopted May 1, 1910.

Eight Strands—19 Wires to the Strand—One Hemp Core.

CRUCIBLE CAST STEEL.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised.
$0.73	1½	4¾	3.19	58	11.6	3.75
.62	1⅜	4¼	2.70	51	10.2	3.5
.51	1¼	4	2.20	42	8.4	3.2
.42	1⅛	3½	1.80	34	6.8	2.83
.34	1	3	1.42	26	5.2	2.5
.27	⅞	2¾	1.08	20	4	2.16
.21	¾	2¼	.80	15.3	3.06	1.83
.16	⅝	2	.56	10.9	2.18	1.75
.14	9/16	1¾	.45	8.7	1.74	1.5
.12	½	1½	.35	7.3	1.46	1.33
.11	7/16	1¼	.27	5.7	1.14	1.16
.10½	⅜	1⅛	.20	4.2	.84	1
.10¼	5/16	1	.13	2.75	.55	.83
.10	¼	¾	.09	1.80	.36	.75

EXTRA STRONG CRUCIBLE CAST STEEL.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised.
$0.88	1½	4¾	3.19	66	13	3.75
.75	1⅜	4¼	2.70	57	11	3.5
.62	1¼	4	2.20	47	9.4	3.2
.51	1⅛	3½	1.80	38	7.6	2.83
.41	1	3	1.42	29.7	5.9	2.5
.32	⅞	2¾	1.08	23	4.6	2.16
.25	¾	2¼	.80	17.6	3.5	1.83
.18½	⅝	2	.56	12.4	2.5	1.75
.16	9/16	1¾	.45	10.1	2	1.5
.14	½	1½	.35	8	1.6	1.33
.13	7/16	1¼	.27	6.30	1.26	1.16
.12¼	⅜	1⅛	.20	4.66	.93	1
.12	5/16	1	.13	3.05	.61	.83
.11¾	¼	¾	.09	2.02	.40	.75

PLOW STEEL.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised.
$1.03	1½	4¾	3.19	74	14.8	3.75
.87	1⅜	4¼	2.70	64	12.8	3.5
.72	1¼	4	2.20	52	10.4	3.2
.60	1⅛	3½	1.80	43	8.6	2.83
.48	1	3	1.42	33	6.6	2.5
.38	⅞	2¾	1.08	26	5.2	2.16
.29	¾	2¼	.80	20	4	1.83
.21	⅝	2	.56	14	2.8	1.75
.18	9/16	1¾	.45	11.6	2.32	1.50
.16	½	1½	.35	8.7	1.74	1.33
.15	7/16	1¼	.27	6.90	1.38	1.16
.14	⅜	1⅛	.20	5.12	1.02	1
.13½	5/16	1	.13	3.35	.67	.83
.13¼	¼	¾	.09	2.25	.45	.75

MONITOR PLOW STEEL.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised.
$1.19	1½	4¾	3.19	80	16	3.75
.98	1⅜	4¼	2.70	68	13	3.5
.82	1¼	4	2.20	56	11	3.2
.68	1⅛	3½	1.80	46	9.2	2.83
.55	1	3	1.42	36	7.2	2.5
.43	⅞	2¾	1.08	28	5.6	2.15
.34	¾	2¼	.80	22	4.4	1.83
.25	⅝	2	.56	15	3	1.75
.22	9/16	1¾	.45	12	2.4	1.5
.19	½	1½	.35	9.5	1.9	1.33

Add 10% to list prices for galvanized rope.

SPECIAL FLEXIBLE HOISTING ROPE.

Six strands of thirty-seven wires each make a special flexible rope which is largely used on electric travel cranes and for large dredge ropes. It permits the use of fairly small sheaves and bends over them easily. This rope comes in diameters of ½-in. variation, but is much better in the larger size than the extra strong on account of the smaller hemp core.

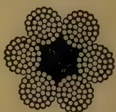


Fig. 253. 6 Strands — 37 Wires to the Strand —One Hemp Core.

LIST PRICES SPECIAL FLEXIBLE HOISTING ROPES

(Standard Strengths, Adopted May 1, 1910)

Six Strands—37 Wires to the Strand—One Hemp Core

CRUCIBLE CAST STEEL.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot	Approx. Strength in Tons of 2,000 Lbs.	Proper working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised.
$2.30	2¾	8⅝	11.95	200	40	...
1.92	2½	7⅞	9.85	160	32	...
1.60	2¼	7⅛	8	125	25	...
1.35	2	6¼	6.30	105	21	...
1.05	1¾	5½	4.85	84	17	...
.89	1⅝	5	4.15	71	14	...
.79	1½	4¾	3.55	63	12	3.75
.65	1⅜	4¼	3	55	11	3.5
.55	1¼	4	2.45	45	9	3.2
.46	1⅛	3½	2	34	7	2.83

CRUCIBLE CAST STEEL—Continued.

List Price per Foot.	Diameter in Inches.	Circumference in Inches.	Approx. Weight per Foot	Approx. Strength in Tons of 2,000 Lbs.	Proper working Load in Tons of 2,000 Lbs.	Diameter of Drum or Sheave in Ft. Advised
$ .37	1	3	1.58	29	6	2.5
.28	7/8	2 3/4	1.20	23	5	2.16
.23	3/4	2 1/4	.89	17.5	3.5	1.83
.18	5/8	2	.62	11.2	2.2	1.75
.15	9/16	1 3/4	.50	9.5	1.9	1.5
.13	1/2	1 1/2	.39	7.25	1.45	1.33
.12 1/2	7/16	1 1/4	.30	5.5	1.1	1.16
.12	3/8	1 1/8	.22	4.2	.84	1

EXTRA STRONG CRUCIBLE CAST STEEL

$2.80	2 3/4	8 5/8	11.95	233	47	...
2.35	2 1/2	7 7/8	9.85	187	37	...
1.90	2 1/4	7 1/8	8	150	30	...
1.55	2	6 1/4	6.30	117	23	...
1.28	1 3/4	5 1/2	4.85	95	19	...
1.07	1 5/8	5	4.15	79	16	...
.95	1 1/2	4 3/4	3.55	71	14	3.75
.78	1 3/8	4 1/4	3	61	12	3.5
.65	1 1/4	4	2.45	50	10	3.20
.55	1 1/8	3 1/2	2	39	8	2.83
.44	1	3	1.58	32	6.4	2.5
.34	7/8	2 3/4	1.20	25	5	2.16
.27	3/4	2 1/4	.89	19	3.8	1.83
.21	5/8	2	.62	12.6	2.5	1.75
.17 1/2	9/16	1 3/4	.50	10.5	2.1	1.5
.15	1/2	1 1/2	.39	8.25	1.65	1.33
.14	7/16	1 1/4	.30	6.35	1.27	1.16
.13	3/8	1 1/8	.22	4.65	.93	1

PLOW STEEL.

$3.30	2 3/4	8 5/8	11.95	265	53	...
2.75	2 1/2	7 7/8	9.85	214	43	...
2.20	2 1/4	7 1/8	8	175	35	...
1.80	2	6 1/4	6.30	130	26	...
1.50	1 3/4	5 1/2	4.85	108	22	...
1.25	1 5/8	5	4.15	90	18	...
1.10	1 1/2	4 3/4	3.55	80	16	3.75
.91	1 3/8	4 1/4	3	68	14	3.5
.75	1 1/4	4	2.45	55	11	3.2
.64	1 1/8	3 1/2	2	44	9	2.83
.51	1	3	1.58	35	7	2.5
.40	7/8	2 3/4	1.20	27	5	2.16
.31	3/4	2 1/4	.89	21	4	1.83
.24	5/8	2	.62	14	3	1.75
.20	9/16	1 3/4	.50	11.5	2.3	1.5
.17	1/2	1 1/2	.39	9.25	1.85	1.33
.16	7/16	1 1/4	.30	7.2	1.4	1.16
.15	3/8	1 1/8	.22	5.1	1	1

MONITOR PLOW STEEL.

List Price per Ft.	Diameter in Ins.	Circumference in Ins.	Approx. Weight per Ft.	Approx. Strength in tons of 2,000 Lbs.	Proper Working Load in tons of 2,000 Lbs.	Diam. of Drum or Sheave in Ft. Advised
$3.75	2¾	8⅝	11.95	278	55	...
3.15	2½	7⅞	9.85	225	45	...
2.50	2¼	7⅛	8	184	37	...
2.10	2	6¼	6.30	137	27	...
1.75	1¾	5½	4.85	113	23	...
1.45	1⅝	5	4.15	95	19	...
1.25	1½	4¾	3.55	84	17	3.75
1.05	1⅜	4¼	3	71	14	3.50
.86	1¼	4	2.45	58	11	3.20
.75	1⅛	3½	2	46	9.2	2.83
.59	1	3	1.58	37	7.4	2.50
.46	⅞	2¾	1.20	29	5.8	2.16
.36	¾	2¼	.89	23	4.6	1.83
.27	⅝	2	.62	16	3.2	1.75
.23	9/16	1¾	.50	12½	2.5	1.50
.20	½	1½	.39	9.75	1.9	1.33
.18½	7/16	1¼	.30	7.50	1.5	1.15
.17½	⅜	1⅛	.22	5.30	1.06	1

Ropes composed of strands made up of more than 37 wires add 10% to list price of 6x37.

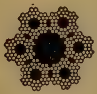


Fig. 254. Six Strands of 42 Wires Each (252 Wires in All)—7 Hemp Cores.

TILLER ROPE OR HAND ROPE.

The 6x6x7 construction is known as tiller rope and is the most flexible rope manufactured. Its first applications were to the steering gear of boats, but its greatest application today is for hand rope on elevators. This is made up of six strands of forty-two wires each and seven hemp cores and comes in diameters of 1/16-in. variation.

PRICES TILLER ROPE OR HAND ROPE

—List Price per Foot— Iron	Crucible Cast Steel	Diameter in Inches	Circumference in Inches	Approx. Weight per Foot Lbs.
$0.33	$0.43	1	3	1.10
.27	.36	⅞	2¾	.84
.22	.30	¾	2¼	.62
.17	.24	⅝	2	.43
.14	.20	9/16	1¾	.35
.11½	.17	½	1½	.28
.10	.15	7/16	1¼	.21
.09	.14	⅜	1⅛	.16
.08	.12½	5/16	1	.11
.07½	.11	¼	¾	.07

The wires are very fine. Care should be taken not to subject it to much abrasive wear.

It is used to a limited extent for steering lines on yachts and motor boats. Galvanized Crucible Cast Steel Yacht Rope, 6 strands, 19 wires to the strand, 1 hemp core, is preferred by many for motor boats.

⅜ and ½-in. diameter Iron Tiller or Hand Rope is used for starting and stopping elevators. This rope is also called Elevator Shipper Rope.

Tiller Rope of tinned or galvanized iron or steel is furnished if required. For this rope add 10% to the foregoing list prices.

FLATTENED STRAND ROPE.

Flattened Strand Ropes are used for heavy derricks, hoists, etc., where great flexibility and long life are required. They are made in a variety of types and steels. Those with an odd number of oval strands are particularly difficult to splice. The best type

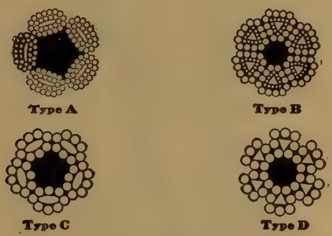


Fig. 255.

is that composed of 6 triangular shaped strands of wire, each strand made up of 12 large outside steel wires, 1 large triangular inside iron wire, with 12 smaller round steel wires between. This comes in the various iron and steels, but we give prices and capacities of Monitor plow steel rope only.

FLATTENED STRAND ROPE

Type A—5 Strands, 28 Wires to the Strand, One Hemp Core

Type B—6 Strands, 25 Wires to the Strand, One Hemp Core

		Type A			Type B			
Diameter in Inches	List Price per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Approx. Weight per Foot	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Approx. Weight per Foot	Diameter of Drum or Sheave in Feet Advised
2¼	$2.85	210	42	8.00	231	46.2	9.20	12
2	2.25	166	33.2	6.30	183	36.6	7.25	11
1¾	2.08	133	26.6	4.85	146	29.2	5.60	9
1⅝	1.56	110	22	4.15	121	24.2	4.75	8½
1½	1.37	98	10.6	3.55	108	21.6	4.00	8
1⅜	1.12	84	16.8	3.00	92	18.4	3.45	7½
1¼	.89	69	13.8	2.45	76	15.2	2.80	7
1⅛	.71	56	11.2	2.00	62	12.4	2.30	6
1	.60	45	9	1.58	50	10.0	1.80	5
⅞	.49	35	7	1.20	39	7.8	1.38	4½
¾	.375	26.3	5.26	.89	29	5.8	1.00	4
⅝	.28	19	3.8	.62	21	4.2	.72	3½
9/16	.25	14.5	2.9	.50	16	3.2	.58	3
½	.20¾	12.1	2.42	.39	13.3	2.7	.45	2¾

Type C—5 Strands, 9 Wires to the Strand, One Hemp Core

Type D—6 Strands, 8 Wires to the Strand, One Hemp Core

		Type C			Type D			
Diameter in Inches	List Price per Ft.	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Approx. Weight Per Foot	Approx. Strength in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Approx. Weight per Foot	Diameter of Drum or Sheave in Feet Advised
1¼	$0.88	67	13.4	2.55	73	14.6	2.80	9¼
1⅛	.70	52	10.4	2.05	56	11.2	2.30	8
1	.58	42	8.4	1.65	46	9.2	1.80	6¾
⅞	.44	33	6.6	1.24	36	7.2	1.38	6
¾	.35	25	5.0	.92	27	5.4	1.00	5¼
⅝	.25	17½	3.5	.64	19	3.8	.72	4½
½	.16¼	11	2.2	.40	11.9	2.38	.45	3¾

NON-SPINNING HOISTING ROPE.

Standard strengths adopted May 1, 1910.

Eighteen strands, seven wires each, one hemp core.

Non-Spinning Rope is necessary in "back-haul" or single line derricks, in shaft sinking and mine hoisting where the bucket or cage swings free. That of the best type is composed of six strands of seven wires each, laid around hemp core and cov-

Fig. 256.

ered with an outer layer of twelve strands of seven wires each, regular lay. It is made in Swedes iron, crucible cast steel, extra strong crucible cast steel, and plow steel. With a rope of this type the Vermont Marble Co., of West Rutland, Vt., hoisted a large block of marble, hanging free, 250 ft. without its making a half turn. (Fig. 256.)

EXTRA STRONG CRUCIBLE CAST STEEL

List Price per Foot	Diameter in Inches	Approximate Circumference in Inches	Weight per Ft. in Pounds	Approximate Breaking Stress in Tons of 2,000 Lbs.	Proper Working Load in Tons of 2,000 Lbs.	Recommended Diameter of Drum or Sheave in Feet
$1.10	1¾	5½	5.50	101.00	20.2	7.00
.94	1⅝	5	4.90	87.60	17.5	6.50
.80	1½	4¾	4.32	75.00	15.0	6.00
.68	1⅜	4¼	3.60	62.40	12.4	5.50
.56	1¼	4	2.80	51.60	10.3	5.00
.46	1⅛	3½	2.34	43.20	8.6	4.50
.37	1	3	1.73	33.00	6.6	4.00
.29	⅞	2¾	1.44	26.50	5.3	3.50
.22	¾	2¼	1.02	19.60	3.9	3.00
.16½	⅝	2	.70	13.10	2.6	2.50
.14	9/16	1¾	.57	10.70	2.1	2.25
.12½	½	1½	.42	8.10	1.6	2.00
.11½	7/16	1¼	.31	5.80	1.1	1.75
.11	⅜	1⅛	.25	4.60	.92	1.50
PLOW STEEL						
$1.30	1¾	5½	5.50	111.10	22.2	7.00
1.08	1⅝	5	4.90	96.30	19.2	6.50
.93	1½	4¾	4.32	82.50	16.5	6.00
.79	1⅜	4¼	3.60	68.60	13.7	5.50
.65	1¼	4	2.80	56.80	11.3	5.00
.54	1⅛	3½	2.34	47.50	9.5	4.50
.43	1	3	1.73	36.30	7.2	4.00
.34	⅞	2¾	1.44	31.80	6.3	3.50
.26	¾	2¼	1.02	24.60	4.9	3.00
.19	⅝	2	.70	15.75	3.1	2.50
.16	9/16	1¾	.57	12.80	2.5	2.25
.14	½	1½	.42	9.75	1.9	2.00
.13	7/16	1¼	.31	6.85	1.3	1.75
.12½	⅜	1⅛	.25	5.55	1.1	1.50

FLAT WIRE ROPE.

Flat wire rope is composed of a number of wire ropes called flat rope strands of alternate right and left lay, usually of crucible steel placed side by side and sewed together with soft Swedish iron or steel wire. This sewing wire, being softer than the steel strands, acts as a cushion and wears out much faster than the strands themselves. The rope, however, is very easily repaired. As a large reel is not necessary for winding it, it is used principally where space is limited.

Fig. 257. Flat Wire Rope Made of Crucible Cast Steel.

It comes in widths of ½-in. variation.

½ INCH THICK

Width and Thickness in Inches	Weight per Foot in Pounds	Approximate Breaking Stress* in Tons of 2,000 Pounds	Proper Working Load in Tons of 2,000 Pounds	Approx. Price per Pound
½x7	5.90	89	13	$0.12½
½x6	5.10	77	11	.12½
½x5½	4.82	72	10.5	.12½
½x5	4.27	64	9.25	.12½
½x4½	4.00	60	8.50	.12½
½x4	3.30	50	7.25	.13½
½x3½	2.97	45	7.00	.13½
½x3	2.38	36	5.25	.13½

⅜ INCH THICK

Width and Thickness in Inches	Weight per Foot in Pounds	Approximate Breaking Stress* in Tons of 2,000 Pounds	Proper Working Load in Tons of 2,000 Pounds	Approx. Price per Pound
⅜x5½	3.90	55	8	.13½
⅜x5	3.40	50	7.5	.13½
⅜x4½	3.12	47	7	.13½
⅜x4	2.86	43	6	.13½
⅜x3½	2.50	38	5.5	.13½
⅜x3	2.00	30	4.5	.13½
⅜x2½	1.86	28	4	.13½
⅜x2	1.19	18	2.5	.13½

Unless order distinctly specifies to the contrary, the rule for thickness applies to size of strand before sewing.

Wire rope is as flexible as new manila or hemp rope of the same strength, and when used as hauling, hoisting or standing rope is generally more durable. The working load for hoisting and haulage ropes should be about ⅕ the breaking strength; standing rope about ¼; in shafts and elevators from 1/7 to 1/10.

Use the largest drums and pulleys possible, and have them truly aligned with the rope. To increase the capacity of hoisting rope increase the load but not the speed, as the wear increases with the latter. Do not "fatigue" the rope unnecessarily by repeated shocks. A wire rope should be discarded by the time half the diameter of the outside wire is worn away.

Galvanized ropes have about 10 per cent less strength than ungalvanized, and the latter may be protected from the weather by the use of one of the many oil, tar or grease mixtures.

In wire rope the outer fibres of each wire going round the sheaves are in tension, and the inner wires are in compression with a neutral point within the circumference of the rope. As the rope goes round the drum or sheave the result of these differential stresses is to produce a crawling or creeping or sliding of the wire upon each rope. It therefore follows that when thoroughly greased the life of wire rope will be very greatly increased. In *Engineering & Mining Journal* it is reported that the same kind of rope well oiled made 386,000 turns over 24" pulley before breaking, as against 75,000 turns when not oiled; a difference in favor of oiling of over 500 per cent. In mine work when a rope is coated with cable compound once a week a steel wire rope of best grade 1½" in diameter with an ultimate strength of about 100 tons will last from 1 to 1½ years.

* Crucible steel will average 30% to 50% stronger than the figures in these columns.

To prevent kinking, the cage should be lowered to the bottom of the shaft and the rope removed, being allowed to hang loose to uncoil.

In the Rookery Building, Chicago, 44 Swedish iron hoisting cables, ⅝" diameter, of six strands of nineteen wires each, four cables to an elevator, have been running twelve years, without replacement. They are lubricated twice a year and carefully inspected each month. The hand rope in the same elevators, however, wears out very rapidly on account of the abrasion caused by the eye holes.

CABLE ON BROOKLYN BRIDGE.

Cables in Order of Service	Term of Service Days	Distance Hauled	Passengers Hauled	Ton miles Hauled	Average Load, Tons	Average Rate of Live to Dead Loads
1	1,140	228,329	49,002,442	22,142,000	97	6
2	607	120,232	47,840,000	25,292,890	212	7.3
3	393	82,099	36,971,000	20,345,073	348.4	7.6
4	356	74,111	34,134,640	18,923,469	255.3	7.6
5	520	111,116	56,287,452	33,857,669	304.7	8.3
6	509	109,475	58,071,000	35,149,894	321.1	8.4

The life of street railway cable is likely to range from 60 to 115,000 miles where the cable itself is between 13,000 and 33,000 feet long. The average of 12 cables of which we have record is 74,017 miles.

A cable used on a Lidgerwood Unloader Plow on the Panama Canal work was installed April 12, 1909, and was first broken May 5, 1910. In the thirteen months it unloaded 1,830 nineteen-car trains of spoil from Culebra. This is a record, as the pull on these cables ranges from 90 to 125 tons. The life of the cable on this work averages from 350 to 500 trains. After breaking, the cables are spliced and used again.

The principal causes of destruction of wire ropes are:

(a) The wearing of the outer surface of the outside wires.

(b) The fatigue of the steel where the rope is worked over small pulleys.

As an example of the first case, the cable on cable tramways is worn by the grips; therefore, use a stiff cable with large wires; as an example of the second case, ropes used over small blocks break frequently; therefore, use a rope with small wires. The strength of a wire rope is about 10 per cent less than the sum of the strengths of the wires composing the rope.

A wire rope-way was constructed for the Plimosas Line consisting of an endless rope 20,230 feet long supported at intervals of from 104 to 1,935 feet on notch sheaves. "After the rope had been running about two years the splices commenced to give way at the points where the two cable strands are inserted into the rope to take the place of the hemp heart. * * * When

new rope is spliced with old the new strands stand out somewhat more than the old ones and the wear is very rapid. * * * A flexible wire rope (19 wires to the strand) can be spliced so that there will be little difference in the wear; but, in a rope of seven-wire strands made out of plow steel, at the point just above and below where the two steel strands are inserted into the core and take the place of the hemp heart, there is a spot (about an inch in length) where the rope is seven strands instead of six on the circumference. This makes the diameter greater and increases the wear on the splice. * * * In a flexible rope the strands can be set together with a mallet so that the splice cannot be noticed."

DIRECTIONS FOR SPLICING WIRE ROPE.*

Wire rope is susceptible to the most perfect splice; a smoother and better splice can be put in a wire rope than in any other kind of rope, for the simple reason that it is made with a view to this purpose. It has the desired number of strands and a hemp core which provides a place for fastening the ends. It is a plain, simple process, and but the work of an hour for any one to learn.

To Get the Length of the Rope to Be Spliced Endless.

In most cases the ropes can be applied endless, and in such cases the ropes can be forwarded spliced ready to go on. Ropes ready spliced can be procured by giving the exact distance from center to center of shaft, and the exact diameters of the wheels on which the rope is to run. This measure can be got best by stretching a wire from shaft to shaft, marking the distance from center to center of shaft and carefully measuring the wire.

In cases where the endless rope cannot be put on, the rope has to be put around the sheaves, hove taut by pulley blocks, and the splice made on the spot. See Fig. 1 in diagram of splices.

The Necessary Tools. A hammer and sharp cold chisel for cutting the ends of strands; a steel point or marlin spike for opening strands; two slings of tarred rope with sticks for untwisting rope; a pocket knife for cutting the hemp core; a wooden mallet and block.

First. Put the rope around the sheaves, and heave it tight with block and fall. (See Fig. 1.) The blocks should be hitched far enough apart so as to give room between to make a 20-ft. splice. A small clamp may be used to prevent the lashing from slipping on the rope where the blocks are hitched. (See Fig. 1.) Next, see that the ropes overlap about 20 feet; about ten feet each way from the center, as shown by the arrow lines in Fig. 1. Next mark the center on both ropes with a piece of chalk, or by tying on a small string. Now proceed to put in the splice, with the blocks remaining taut when it is necessary; but the better way is to remove the blocks, throw off the rope from the sheaves, let it hang loose on the shafts, and proceed with the splice on the ground or floor, or scaffold, as the case may be.

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* Abstracted from catalogue of Broderick & Bascom Rope Co.

Second. Unlay the strands of both ends of the rope for a distance of ten feet each, or to the center mark, as shown in Fig. 2. Next, cut off the hemp cores close up, as shown in Fig. 2, and bring the bunches of strands together so that the opposite strands will interlock regularly with each other. (See Fig. 3.)

Third. Unlay any strand, A, and follow up with strand 1 of the other end, laying it tightly in open groove made by unwinding A, make twist of the strand agree exactly with the twist of the open groove. Proceed with this until all but twelve inches of 1 are laid in, or till A has become ten feet long. Next, cut off A, leaving an end about twelve inches long.

Fourth. Unlay a strand, 4, of the opposite end, and follow with strand D, laying it into the open groove as before, and

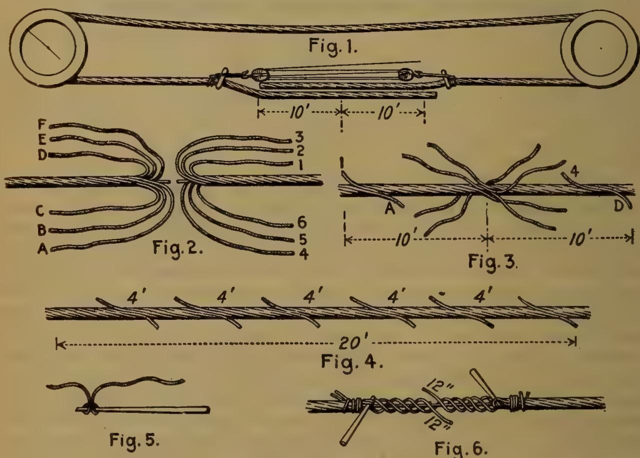

Fig. 258.

treating this precisely as in the first case. (See Fig. 3) Next, pursue the same course with B and 2, stopping four feet short of the first set. Next, with 5 and E, stopping as before; then with C and 3; and lastly with 6 and F. The strands are now all laid in with the ends four feet apart, as shown in Fig. 4.

Fifth and Last. The ends must now be secured without enlarging the diameter of the rope. Take two rope slings or twisters (see Fig. 5) and fasten them to the rope as shown in Fig. 6; twist them in opposite directions, thus opening the lay of the rope. (See Fig. 6.) Next, with a knife, cut the hemp core about twelve inches on each side. Now straighten the ends, and slip them into the place occupied by the core; then twist the slings back, closing up the rope, taking out any slight inequality with a wooden mallet. Next, shift the slings, and repeat the operation at the other five places, and the splice is made.

If the rope becomes slack, in time, and runs too loose, a piece

can be cut out and the rope tightened up. This will require a piece of rope about 40 feet long and two splices, one splice to put on the piece of rope and the other splice to join the two ends together.

COST FOR LABOR OF SPLICING ROPE TO MAKE ENDLESS.

Diameter of Rope in Inches	"List" for Splicing	Diameter of Rope in Inches	List for Splicing
¼ to 5/16	$2.50	⅞ to 1⅛	$4.00
⅜ to 7/16	3.00	1¼ to 1½	4.50
½ to ¾	3.50		

The above charge to be in addition to the extra rope used in making splice. These prices apply only on wire ropes spliced at the works of the manufacturer.

MANILA AND SISAL ROPE.

Manila and sisal rope are usually classed as "regular" rope or rope having three strands, four strand rope, bolt rope or especially selected long yarns and transmission rope which is of yarn selected and woven with great care. The prices are computed from a "base" which varies with the season and according to the condition of the trade; this base averages 8 cents per lb.

The table below gives the standard sizes, weights, etc.

MANILA ROPE

Size in Circumference	Size in Diameter	Weight of 200 Faths. Manila in Lbs.	Strain Borne by New Manila Rope	Length of Manila Rope in One Pound
6 th'd	¼ in.	22	620	55 ft.
9 th'd	5/16 in.	29	1,000	41 ft.
12 th'd	⅜ in.	44	1,275	27 ft.
15 th'd fine	⅜ in. full	50	1,600	24 ft.
15 th'd	7/16 in.	65	1,875	18 ft. 6 in.
1⅜ in.	7/16 in. full	75	2,100	16 ft. 0 in.
1½ in.	½ in.	90	2,400	13 ft. 4 in.
1¾ in.	9/16 in.	125	3,300	9 ft. 7 in.
2 in.	⅝ in.	160	4,000	7 ft. 6 in.
2¼ in.	¾ in.	198	4,700	6 ft. 1 in.
2½ in.	13/16 in.	234	5,600	5 ft. 1 in.
2¾ in.	⅞ in.	270	6,500	4 ft. 5 in.
3 in.	1 in.	324	7,500	3 ft. 8 in.
3¼ in.	1 1/16 in.	378	8,900	3 ft. 2 in.
3½ in.	1⅛ in.	432	10,500	2 ft. 9 in.
3¾ in.	1¼ in.	504	12,500	2 ft. 5 in.
4 in.	1 5/16 in.	576	14,000	2 ft. 1 in.
4¼ in.	1⅜ in.	648	15,400	1 ft. 10 in.
4½ in.	1½ in.	720	17,000	1 ft. 8 in.
4¾ in.	1 9/16 in.	810	18,400	1 ft. 6 in.
5 in.	1⅝ in.	900	20,000	1 ft. 4 in.
5½ in.	1¾ in.	1,080	25,000	1 ft. 1 in.
6 in.	2 in.	1,296	30,000	11 in.
6½ in.	2⅛ in.	1,512	33,000	9½ in.
7 in.	2¼ in.	1,764	37,000	8 in.
7½ in.	2½ in.	2,016	43,000	7 in.
8 in.	2⅝ in.	2,304	50,000	6¼ in.
8½ in.	2⅞ in.	2,590	56,000	5½ in.
9 in.	3 in.	2,915	62,000	5 in.
9½ in.	3⅛ in.	3,240	68,000	4½ in.
10 in.	3¼ in.	3,600	75,000	4 in.

Sisal rope has approximately the same weight as Manila.
Manila about 25 per cent stronger than sisal.
Hawser laid rope weighs about one-sixth less than 3 strand.
The prices of rope are as follows:

Regular Rope, 3/16 in. diameter, 1½c over base.
¼ in. and 5/16 in. diameter, 1c over base.
⅜ in. diameter, ½c over base.
7/16 in. diameter and larger, base.

Four Strand Manila, ⅝ in. diameter and under, 1c over base.
Manila Bolt Rope, 2c over base.
Towing Hawsers, up to 18-in. circumference and any length, base.
Tarred Sisal Lath Yarn, coarse (110), medium (130), base.
fine (200), ½c per lb. over base.
Tarred Sisal Fodder Yarn, 24 and 21 oz., base, 18 oz., 1½c above base.
Drilling Cables, 1c above base.
Sand Lines, 1c above base.
Jute Rope (unoiled)—

¼ in. diameter and larger, base.
3/16 in. diameter and larger, ½c above base.

TABLE 146—MANILA TRANSMISSION ROPE.

Diam. Inches	Approximate Wt. in Lbs. per 100 Ft.	Approximate Breaking Strength	Length in Ft. Required for Splice	Smallest Diam. of Sheave
¾	20	4500	8	28
⅞	26	6125	8	32
1	34	8000	10	36
1⅛	43	10125	10	40
1¼	53	12500	10	46
1⅜	65	15125	12	50
1½	77	18000	12	54
1⅝	90	21125	12	60
1¾	104	24500	12	64
2	136	32000	14	72

Price 11c to 15½ cents per pound.

TENSILE STRENGTH OF DIFFERENT KINDS OF WIRE ROPE, COMPARED WITH MANILA ROPE

TABLE 147—APPROXIMATE BREAKING STRESS CALCULATED IN TONS OF 2,000 POUNDS.

Diameter in Inches	Wire Transmission Rope. One Hemp Core Surrounded by Six Strands Seven Wires Each				Wire Hoisting Rope. One Hemp Core Surrounded by Six Strands of Nineteen Wires Each				
	Iron Tons	Crucible Cast Steel Tons	Extra Strong Crucible Cast Steel Tons	Plow Steel Tons	Iron Tons	Crucible Cast Steel Tons	Extra Strong Crucible Cast Steel Tons	Plow Steel Tons	Average Quality New Manila Rope Tons
2¾	...	...	....	...	111	211	243	275	26
2½	...	...	....	...	92	170	200	229	21
2¼	...	...	....	...	72	133	160	186	17
2	...	...	....	...	55	106	123	140	13½
1¾	...	...	....	...	44	85	99	112	11
1⅝	...	...	....	...	38	72	83	94	9½
1½	32	63	73	82	33	64	73	82	8
1⅜	28	53	63	72	28	56	64	72	7
1¼	23	46	54	60	22.8	47	53	58	6
1⅛	19	37	43	47	18.6	38	43	47	5
1	15	31	35	38	14.5	30	34	38	4
⅞	12	24	28	31	11.8	23	26	29	3
¾	8.8	18.6	21	23	8.5	17.5	20.2	23	2¼
⅝	6	13	14.5	16	6	12.5	14	15.5	1½
9/16	4.8	10	11	12	4.7	10	11.2	12.3	1¼
½	3.7	7.7	8.85	10	3.9	8.4	9.2	10	1
7/16	2.6	5.5	6.25	7	2.9	6.5	7.25	8	¾
⅜	2.2	4.6	5.25	5.9	2.4	4.8	5.30	5.75	½
5/16	1.7	3.5	3.95	4.4	1.5	3.1	3.50	3.8	⅜
9/32	1.2	2.5	2.95	3.4	...	...	...	....	3/10
¼	...	...	....	...	1.1	2.2	2.43	2.65	¼

Mr. George J. Bishop in 1897 made some records to determine the life of manila rope in pile driving. The drum of the engine and the sheave on the top of the leads were 14″ in diameter. The sheave at the front of the pile driver was 10″. The hammer weighed 10,000 lbs. The rope was of three different makes of 1½″ diameter. Common manila three-ply rope made the best showing. The length of rope was 125′, and its weight ranged from 74 to 95 lbs.; average 85 lbs., or nearly 0.7 lbs. per foot. The price of the rope was 6½ cents per lb., or $5.53 per average rope. Ten ropes were used up in driving 1,335 piles to an average penetration of 20′; hence, each rope averaged 135 piles at a cost of 4 cents per pile per rope. However, 5 ropes averaged only 101 piles each, and 5 averaged 166 piles each.

The Plymouth Cordage Company in 1910-11 conducted a series of tests on various brands of rope to determine the extent to which manila rope might vary in quality. An average Plymouth cordage sample was used as a standard and from this the variations plus or minus, in size, weight and strength were plotted

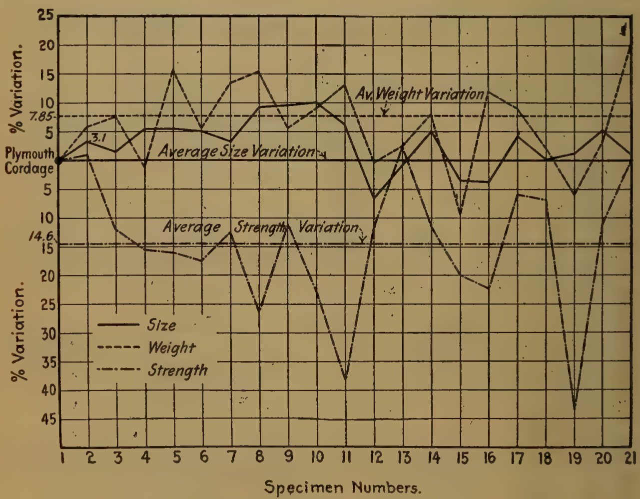

Fig. 259. Diagram Showing Variation of Wire Rope from Standard Plymouth Cordage.

on the accompanying diagram. Twenty-two samples of rope nominally 3 ins. in circumference, made by various manufacturers, were tested. The strongest rope failed under a load of 9,010 lbs., while the weakest was able to stand only 4,946 lbs. Glancing at the table it will be seen that in several cases where the size curve shows a decided rise the weight curve dips. It

would be natural to suppose that the weight would increase correspondingly with the size, but this does not seem to be the case and must indicate that some brands are more loosely twisted than others. As will be noticed the weights vary between minus 9.61% and plus 20% and the table shows that so-called 3 in. rope is not always 3 ins. in circumference.

SAND BLAST MACHINES

A portable sand blast machine, 20 ins. diameter, 52 ins. total height, fitted with water trap and pressure gauge, helmet to protect operator, nozzle holder and 24⅜x5 ins., hard iron nozzles, costs about $190. A machine of this kind may be used for many purposes, among them to clean or finish concrete surfaces. A 2-in. hose connection is regularly furnished with the machine, but a 1-in. sand blast hose, costing about $1 per ft., would facilitate operations. To furnish air at 50 to 60 lbs. pressure would require a compressor having a capacity of 120 cubic feet of free air per minute, which would be a 10x10x10 steam driven machine. Two to three feet of surface may be cleaned per minute.

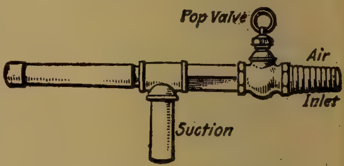

Fig. 260. Portable Sand Blast.

At the United States Naval Station, Key West, Fla., steel sheds were cleaned and painted by compressed air. These sheds were used to store coal and the action of heat and the impurities in the coal, combined with the salt water used for extinguishing spontaneous combustion fires, rapidly corroded the steel and necessitated a thorough cleaning and painting every time the sheds were emptied. The following outfit was purchased and cost $2,090:

1 horizontal gasoline engine, about 20 H. P.
1 air compressor, capacity about 90 ft. of free air per min. compressed to a pressure of 30 lbs. per sq. in. in one stage, belt connected to engine.
1 rotary circulating pump, belt connected to engine.
1 galvanized steel water tank.
1 air receiver, 18x54 ins.
(The above apparatus was all mounted on steel frame wagon with wooden housing.)
2 sand blast machines, capacity 2 cubic feet of sand each.
2 paint spraying machines, one a hand machine of ⅔ gal. capacity for one operator, the other of 10 gals. capacity for two operators.
100 lin. ft. of sand blast hose.
200 lin. ft. of pneumatic hose for sand blast machines.
400 lin. ft. of pneumatic hose for painting machines.
100 lin. ft. of air and paint hose for painting machines.
4 khaki helmets, with mica-covered openings for the eyes.
200 lin. ft. of 2-in. galvanized iron pipe.

Cleaning by hand cost over 4 cents per square ft. The labor cost per day of cleaning by machine is shown on the following page.

1 engine tender	$ 3.04
1 helper (in charge of the work and tending machines)	2.24
2 laborers on machines at $1.76 each	3.52
1 laborer drying sand, filling machines, etc	1.76
Total	$10.56

9,000 square feet of surface were cleaned at a cost for labor of $97.68 and for gasoline of $16.15, or at the rate of less than 1½ cents per square foot; 9,000 square feet of surface were painted at a cost for labor of $28.16 and for gasoline of $3.80, or at the rate of ⅖ cent per square foot. The interest, depreciation and repairs to plant would add an inconsiderable amount to this.

SAW MILLS

A light weight medium sized portable mill with standard equipment, including variable friction feed, cable drive, mud sills, self-oiling and self-aligning mandrel boxes, binding pulley and frame for drive belt, 2 cant hooks, monkey wrench, oil can and belt punch. Fig. 261.

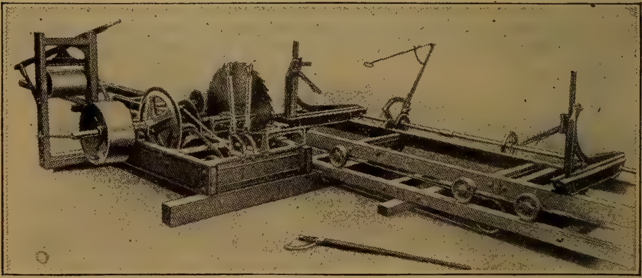

Fig. 261. Eclipse No. 01 Saw Mill.

SPECIFICATIONS

Will swing 56 in. saw.
Husk, 4 ft. 1 in. x 5 ft. 11 in. long.
Mandrel, 2⅝ in. diam., 72 in. long.
Mandrel pulley, 24 in. diam., 10 in. face.
Carriages built in standard lengths, 20, 25 and 30 ft.
Knees, open, 38 in.
Feed, ½ in. to 2¾ in. to each revolution of saw.
Capacity, with 15 H. P. engine, 3,000 to 5,000 feet per day.

Price with 20 ft. carriage, 55 ft. ways, f. o. b. N. Y. (not including saw)	$293.00
Necessary extras, as paper wheel fillings, saw guide jaws, dog springs, etc.	22.00
Third head block with dogs	16.00
Foot receder and gauge roll	40.00
Longer carriage, per foot	3.50
Axles and wheels for log carriage	9.50

Weight, net, 5,316 lbs.
Weight, boxed, 7,531 lbs.
Cubic feet space, boxed, 343 cu. ft.

An extra strong portable mill with standard equipment.

SPECIFICATIONS

Will swing 62 in. saw.
Husk, 4 ft. 4 in. x 9 ft. long.
Mandrel, 3x78 in.
Mandrel pulley, 24x12 in.
Carriage lengths, 20, 25 and 30 ft.
Feed, ½ to 4 in.
Knees, open, 44 in.
Capacity with 20 H. P. engine, 5,000 to 8,000 ft. per day.

Price with 20 ft. carriage, 55 ft. ways, f. o. b. N. Y. (not including saw)	$312.00
Necessary extras for renewals	23.00
Third head block and dogs	20.00
Foot receder and gauge roll	40.00
Longer carriage, per foot	4.00
Taper movements on head blocks, each	8.50

Weight, net, 7,096 lbs.
Weight, boxed, 8,885 lbs.
Cubic feet space, boxed, 400 cu. ft.

Inserted tooth saws, 54 in	$ 90.00
Inserted tooth saws, 56 in	100.00

Fig. 262 illustrates a well-known type of rip saw which comes in various sizes as per specifications.

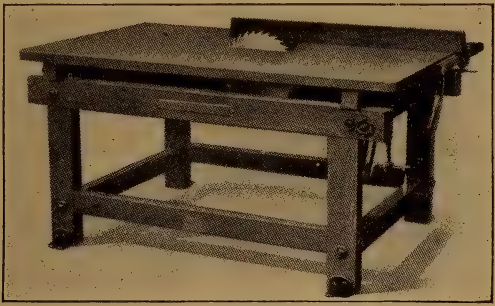

Fig. 262. Wood Frame Rip Saw.

Size No. 1 wood frame saw table, without countershaft. **Price,** f. o. b. factory, $48.

SPECIFICATIONS.

These machines have hardwood frames, well seasoned, carefully mortised and firmly bolted together.

The Top is made of narrow strips of different wood glued together, being fastened to cross girts cannot warp or split, and is raised or lowered by crank and screw at front and locked in place by finger wheels at side, heavy hinges being used at the rear of the machine.

The Saw Arbor is of the cone bushing, self-oiling type, having connected babbitted boxes with the pulleys placed on the outside unless ordered otherwise.

A Square Ripping Gauge is furnished and one 14″ saw, which extends from 2 to 3¼″ above table, according to machine ordered.

A Bevel Rip Gauge in place of the regular rip gauge can be furnished when so ordered, at a slight additional cost.

TABLE 148.—PARTICULARS OF WOOD FRAME SAW TABLES.

Table	For Saws	Hole	Pulley	Speed	Horsepower	Wt., Lbs.	Boxed for Export Wt., Lbs.	Boxed for Export Cu. Ft.
2′ 7″ x 4′	— to 14″	⅞″ to 1¼″	4 ″ x 5″	2700	5 to 7½	250	325	36
2′ 10″ x 4′ 8″	14″ to 16″	1 ″ to 1½″	4½″ x 5″	2400	5 to 10	300	375	45
3′ x 5′	16″ to 20″	1⅛″ to 1⅝″	5 ″ x 6″	2000	7½ to 15	350	425	55
3′ 4″ x 5′ 6″	20″ to 24″	1¼″ to 1¾″	5½″ x 6″	1500	7½ to 15	400	500	65
3′ 6″ x 6′	24″ to 30″	1⅜″ to 2 ″	6 ″ x 7″	1250	10 to 20	450	560	75
3′ 8″ x 6′	30″ to 36″	1½″ to 2¼″	8 ″ x 8″	1000	10 to 20	500	625	85

Bevel rip gauge in place of plain gauge, extra.
Arbor pulley can be placed inside of frame.

SAWS—PORTABLE

A small portable circular saw, mounted upon a durable frame, costs $12.00, and may be run by a one-cylinder farm engine costing about $75.00. These saws are invaluable where the construction of wood frame buildings is concerned as well as being in constant demand by the farmer for use about his place.

SCALES

Counter scoop scales weighing up to 5 lbs. cost from $2 to $5.

Portable Platform Scales adapted to the weighing of all kinds of general merchandise.

Capacity, lbs...........	400x¼	800x½	1500x½	2500x½
Size of platform, inches.	16x22	17x26	21x28	26x34
Weight, approx. pounds.	125	200	300	400
Price without wheels...	$13.00	$20.00	$30.00	$48.00
Price with wheels......	15.00	22.00	33.00	51.00

Wheelbarrow scales, with runs on both sides for wheelbarrows and hand trucks.

Capacity, pounds	1,000	1,500	2,000	2,500
Platform, inches	42x30	42x30	44x35	45x36
Price without wheels...	$42.00	$48.00	$49.00	$69.00
Price with quick weigher	66.00	....	....	....
Price with wheels......	45.00	51.00	60.00	75.00
Price with quick weigher	69.00	....	....	....

A Steel Pitless Wagon Scale which can be easily moved at a cost of $20 to $30, complete with frame and scale costs as follows:

4 ton, weight 1,400 lbs. Price............................$100.00
5 ton, weight 1,500 lbs. Price............................ 110.00

Standard wagon and stock scales without timber or foundation cost as follows:

Capacity, tons	3	5	10	15	20
Size of platform feet...	14x8	14x8	18x8	22x7	22x7
Price	$80.00	$100.00	$120.00	$210.00	$250.00

A Car Scale of 10 tons capacity, with a platform 4′ 6″x8′, costs, without platform, framing, or material for pit, $150. The frames take about 1,000 feet B. M. of lumber and cost erected about $45. The foundation, including the boxing of the pit, will cost from $75 to $100.

A Steelyard or Weighmaster's Beam with a capacity of 2,000 lbs., beam 7′ 10″ long, weighing 127 lbs., costs $28.

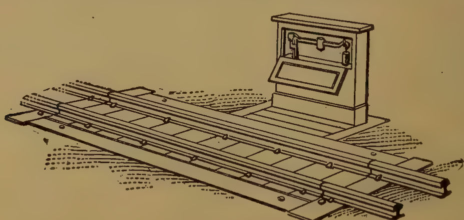

Fig. 263.

A Track Scale (Fig. 263) for weighing of material in small cars is as follows:

Capacity, tons	2	3	5	6
Size of platform	5'x30"	5'x30"	5'x30"	12'x30"
Weight, lbs.	750	780	900	1,500
Price	$72.00	$80.00	$88.00	$130.00

Wooden parts for 2 and 3 ton scales $28 extra. For double beam add $5.

Cost of Track Scales.* On the New York Central a 100-ton track scale, 42 ft. long, cost as follows, in 1902:

Scales and materials	$1,760.00
Labor	640.00
Total	$2,400.00
8.7 tons rails (relayers), at $20	174.00
15 ties at $0.60	9.00
Miscellaneous material	150.00
Labor laying track, etc	70.00
Grand total	$2,803.00

No piles were used in foundation.

The cost of 50-ton track scales, 42 ft. long, on the Northern Pacific, in 1899, averaged as follows:

Scales, delivered	$ 580.00
Other materials	170.00
Labor ($175 to $300)	250.00
Total	$1,000.00

The cost of 80-ton track scales, 50 ft. long, in 1905, was as follows:

Scales and materials	$1,250.00
Labor ($500 to $700)	650.00
Total	$1,900.00

* Hand Book of Cost Data, by H. P. Gillette.

SCARIFIERS

A scarifier illustrated in Fig. 264, which can be pulled by a 10-ton roller, and whose depth of loosening can be regulated by the man in charge while in operation, costs $500.

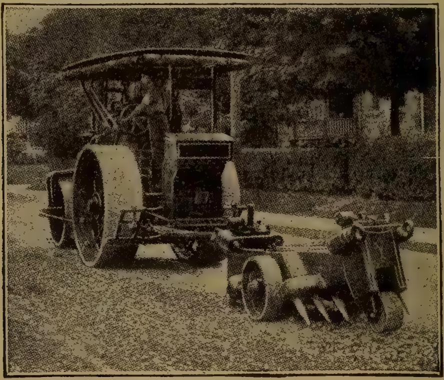

Fig. 264.

Another type of scarifier, built on the same general lines as a road machine, is shown in Fig. 265. This machine has 13 teeth, 1x2 ins.x20 ins. long, with a cutting depth below frame of 9 ins. The extreme width of cut is 4 ft. 8 in. The machine is reversible

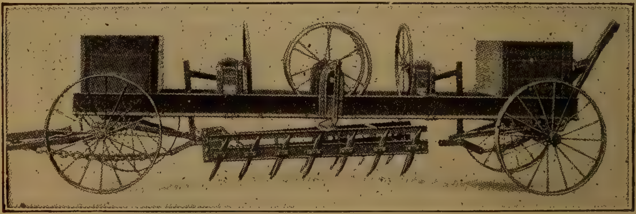

Fig. 265. New Scarifier.

and is 13 ft. 8½ ins. long, axle to axle, weighs 2,900 lbs., and costs $500, f. o. b. New York state.

One of these machines was recently tried out on a hard cemented macadam pavement. Previous to the use of the scarifier, the work of ripping up the pavement was done by hand at the following cost:

20 men with picks at $2.00 per day	$40.00
Sharpening 80 picks at 10c	8.00
Foreman	3.00
Cost per day for 170 ft. of road 16 ft. wide	$51.00
Cost per mile	$1,585.00

The cost by machine was as follows:

Operator on machine	$ 2.50
Sharpening picks	2.50
Roller operator	3.00
Fuel, etc.	2.00
Rent of roller	10.00
Cost per day for 1818 ft. of road 16 ft. wide	$20.00
Cost per mile	$57.00

SCRAPERS

(See Grading Machines, page 335.)

SCREENS

Ordinary sand and coal screens cost from $3 to $12 each. Revolving screens with rollers and gears, but no frame nor driving mechanism cost as follows:

Size	Price	Weight, Lbs.
32 ins. x 8 ft.	$160.00	3,800
32 ins. x 10 ft.	175.00	4,300
32 ins. x 12 ft.	190.00	4,500
40 ins. x 16 ft.	335.00	6,600
40 ins. x 20 ft.	385.00	7,400
48 ins. x 20 ft.	455.00	12,500

Screens in permanent plants should be made of the best steel. A carbon steel screen of ⅜-in. plate, after handling 10,000 to 14,000 yards of crushed trap rock, was reduced to ⅛ inch at the point where the chute delivered it. The holes had been enlarged from $1\frac{3}{16}$ inches to $1\frac{13}{16}$ inches, and from 2¼ inches to 2⅞ inches. A ½-inch rolled manganese steel plate screen replaced the first screen, and after handling 10,000 cubic yards showed no appreciable wear.

SKIPS

SKIPS SIMILAR TO FIGURE 266.

Material	Listed Capacity	Size	Weight (Lbs.)	Price
Wood	1 cu. yd.	5′x5′x14″	650	$40.00
Wood	2 cu. yds.	6′x6′x18″	750	60.00
Steel	⅔ cu. yd.	4′x5′x10″	600	36.00
Steel	30 cu. ft.	5′x6′x12″	700	48.00
Steel	2 cu. yds.	6′x7′x15″	750	65.00
Steel	3 cu. yds.	7′x8′x18″	800	90.00

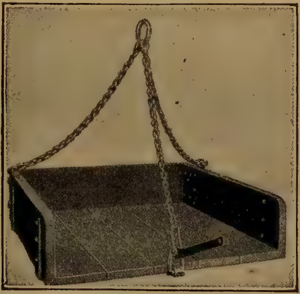

Fig. 266.

SKIPS SIMILAR TO FIGURE 267.

Material	Listed Capacity (Cu. yds.)	Size	Weight (Lbs.)	Price
Steel	1	4′ x5′x18″	725	$ 47.00
Steel	1½	4′6″x6′x18″	850	55.00
Steel	2	5′ x6′x22″	1,350	80.00
Steel	3	6′ x7′x24″	1,700	102.00

Fig. 267.

SKIP WITH BAIL AND CLOSING FRONT.

Material	Listed Capacity	Weight (Lbs.)	Price	Cable Grips
Steel	4 cu. yds.	2,500	$190.00	$25.00

SLEDGES AND HAMMERS

Style	Weight (Lbs.)	Length of Head	Width of Head	Handle Length	Price Each
Stone	8	7½″	2¾″	36″	$1.50
Stone	12	9″	2¾″	36″	2.25
2-face[1]	15	7″	3¼″	36″	2.75
2-face[2]	8	6″	2¾″	36″	1.50
Handdrill	5	7″	2″	14″±	1.25

All weights given without handle, for which add ¾ to 1 lb. Cost of handles, $1.50 per doz.

Double Face and Cross Peen oil finish sledges and hammers, 5-lb. to 24-lb. weight, 7½ cents per lb.; striking and drilling hammers, long pattern, 3 to 4½ lbs., 10 cents per lb.; 5 to 14 lbs., 7½ cents per lb.; stone sledges, 10 to 24 lbs., 7½ cents per lb.

Bricklayer's Hammers. The following are net prices for bricklayer's hammers, in quantities, at Chicago:

Weight Without Handle	Price per Dozen Plain Eye	Adze Eye
1 lb. 2 oz.	$4.95	$5.85
1 lb. 8 oz.	5.40	6.30
2 lbs.	5.85	6.75
2 lbs. 8 oz.	6.30	7.20

Nail and Riveting Hammers, Etc. The following are net prices in Chicago for quantities of nail hammers and riveting hammers:

NAIL HAMMERS.

No.	Weight, Each	Price, Each	Price per Doz.
0	1 lb. 12 oz.	$0.625	$6.25
1	1 lb. 4 oz.	.45	4.50
1½	1 lb.	.425	4.25
2	13 oz.	.40	4.00
3	7 oz.	.375	3.75

The hammers are made of solid steel, polished with adze eye and plain or bell face, as desired.

RIVETING HAMMERS (PLAIN EYE).

No.	Weight, Each	Price, Each	Price per Doz.
0	4 oz.	$0.275	$2.75
1	7 oz.	.275	2.88
2	9 oz.	.30	3.00
3	12 oz.	.30	3.13
4	15 oz.	.33	3.25
5	1 lb. 2 oz.	.35	3.50
6	1 lb. 6 oz.	.375	3.75
7	1 lb. 10 oz.	.40	4.00

Sewer Builders' Mauls. Net prices for mauls for sewer builders, etc., with selected hickory handles and iron bound head, range from $1.40 each for 6x8 and 6x9-in. sizes to $1.50 each for 7x9, $1.60 for 7x10 and $1.70 for 8x10-in.

[1] Blacksmiths' sledge. [2] Striking hammer.

SPRINKLERS

SPRINKLING CARS AND WAGONS, OIL DISTRIBUTORS AND TANK WAGONS.

PLATFORM SPRING GEAR SPRINKLING WAGONS.

Capacity (Gals.)	Weight (Lbs.)	Price
500	2,600	$300.00
600	2,750	325.00
1,000	3,300	350.00

Cut under reach gear.

Capacity (Gals.)	Weight (Lbs.)	Price
600	2,750	$254.00

All of the above fitted with 4-inch tires. Add $12.00 for 6″ tires.

The above wagon fitted with a tank pump, one piece of hose 15 feet long and one piece of hose 12½ feet long costs $25 extra.

A steel tank holding 12 barrels mounted on a steel wheel truck fitted with traction engine tongue and horse tongue costs $96. The same tank unmounted for use on a farm wagon costs $57.50.

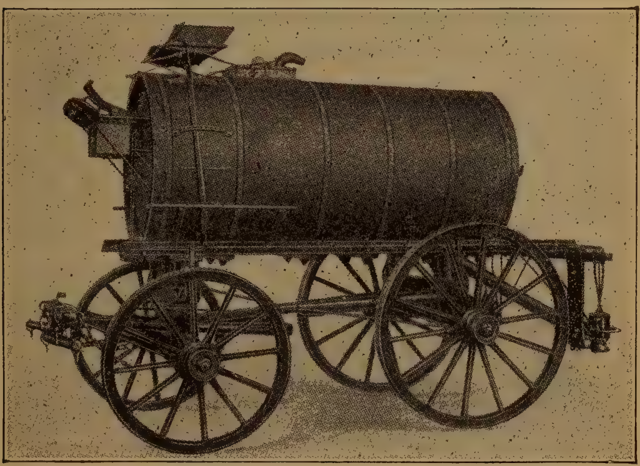

Fig. 268.

A brake for the outfit costs $6. A single cylinder suction pump with hose and strainer for the tank costs $13, and a perforated pipe sprinkling attachment $35.

A 600 gallon tank-wagon for carrying tar, oil or asphalt road binding material fully equipped with driver's seat, pole and whiffle-tree costs $400. Equipped with fire box for keeping contents warm, $500.

A sprinkler with wheels fitted with 8-inch tires and having the rear axle longer than the front, so that the wheels overlap, resulting in a rolled surface of 14 inches on either side, costs $380.

A one-horse sprinkler cart (Fig. 269) holding 150 gallons and weighing 780 lbs., costs $90.

An improved road oiler with a seat for the operator in the rear of the wagon, where he is best able to observe and control the supply of oil, complete with 6-inch tires, steel tank, etc., holding

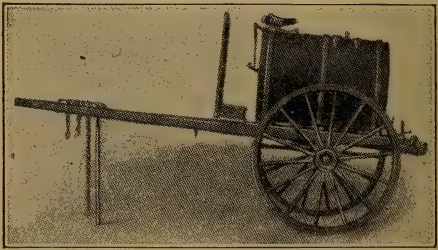

Fig. 269.

600 gallons, costs $350; if fitted with steam coils, $375, and if fitted with heating furnace, which is necessary when spreading heavy oils, $500.

An oil sprinkler and distributor for surface oiling of roads and distributing bituminous binder consists of two horizontal cylindrical tanks with ducts leading to them from the tank wagon, and with a seat, and flow regulating levers. This can be attached very easily to any tank wagon or cart and costs $150.

SHOVELS

No.	Shape	Size of Bowl (Ins.)	Length of Handle (Ins.)	Length Over all (Ins.)	Weight, Each (Lbs.)	Price per Doz.
No. 3,	round	9¼x13	27	40	5½	$7.50
No. 3,	round, light...	10 x12½	27	40	6½	5.25
No. 3,	square	9 x12	27	40	6¼	7.50
No. 3,	square, light..	10 x13	27	40	7	5.25
No. 2,	square	10 x12½	51	61	5½	5.25
No. 4,	square	8¾x12	51	62	5½	7.00

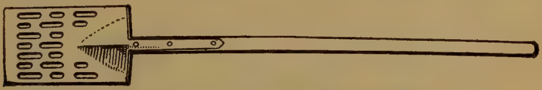

Fig. 270. Concrete Facing Spade.

Concrete Facing Spades similar to Fig. 270 cost about $2.50 each.

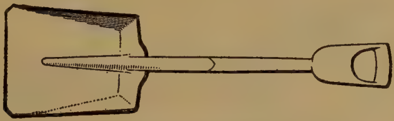

Fig. 271. Ore and Concrete Shovel.

Ore and Concrete Shovels (Fig. 271) with a drop tempered point and annealed blade, well suited for concrete, come in sizes 2 to 6, inclusive, and cost $9.50 per dozen.

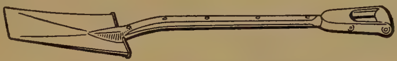

Fig. 272. Nursery Spade.

Nursery Spades (Fig. 272) cost $11 per dozen; ditching spades (Fig. 273) and concave drain spades (Fig. 274), 14 to 18 inches

Fig. 273. Ditching Spade.

long, cost $9 per dozen; post spades (Fig. 275) cost $12 per dozen; and marl gouges (Fig. 276), 10 to 14 inches long, cost $5 to $7 per dozen.

No. 3 to No. 6 Scoops (Fig. 277) cost $7 to $9 per dozen. Iron screening or potato scoops (Fig. 278) cost $12 to $15. Snow shovels (Fig. 279) cost $9 per dozen.

Hand Shovels. Net prices for standard railroad contractors' and mining shovels, at Chicago, in quantities, are as follows with prices for four grades: (1) Extra grade made of best

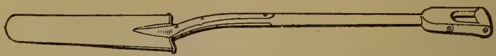

Fig. 274. Concave Drain Spade.

Fig. 275. Post Spade.

Fig. 276. Marl Gouge.

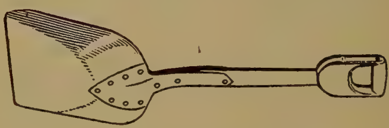

Fig. 277. Scoop.

Fig. 278. Screening Scoop.

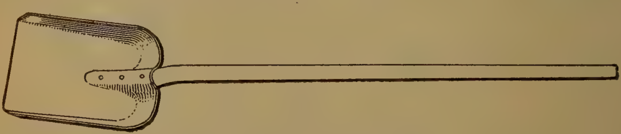

Fig. 279. Snow Shovel.

crucible steel, finely finished with best white ash handles; (2) first grade shovels, also made of crucible steel, and grades (3) and (4) made of open hearth steel. The net prices in Chicago on these four grades are as follows:

PRICES AND SIZES ON HAND SHOVELS.

Size	Size Blade. Width (Ins.)	Size Blade. Length (Ins.)	Extra Grade, per Doz.	1st Grade, per Doz.	2d Grade, per Doz.	3d Grade, per Doz.
2	9½	11¾	$8.91	$7.83	$6.48	$5.70
3	9¾	12¼	9.18	8.10	....	....
4	10½	12½	9.45	8.37	....	....

The above prices are for black finish; for polished add 50 cents per doz. Shovels with square or round points, "D" or long

Fig. 280. D Handle, Round Point Shovel.

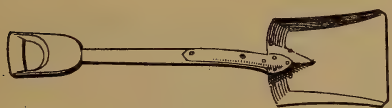

Fig. 281. D Handle, Square Point Shovel.

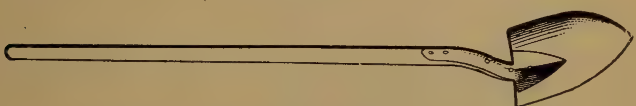

Fig. 282. Long Handle, Round Point Shovel.

handles are all the same price. The size No. 2 is the one commonly used. For sewer or brick shovels made in No. 2 size, but having a shorter and heavier blade for clay and other heavier material, net prices are as follows:

	Each	Per Doz.
Extra grade	$1.00	$10.00
Second grade	.648	6.48

The net prices at Chicago for spades, plain strap, polished, "D" handle or long handle, are as follows: For size No. 2; Extra grade, $9.18 per doz.; fourth grade, $5.40 per doz. Extra grade shovels made the same as "D" handle moulders' shovel, but with straighter, stiffer and heavier blades, for finishing concrete in sidewalks, in forms, etc., sell for $13.86 per doz.

TELEGRAPH SHOVELS AND SPOONS.

Telegraph shovels made of fine crucible steel with white grained ash handles, and extra length 22-in. straps and black finish, can be bought in quantities at the following net prices, f. o. b. Chicago.

Length of Handle	Extra Grade per Doz.	First Grade per Doz.
6′	$12.69	$11.07
7′	13.77	12.15
8′	14.85	13.23
9′	17.00	15.39
10′	19.17	16.65

The net prices in quantities for telegraph spoons with regular 9-in. straps and black finish are as follows:

Length of Handle	Extra Grade per Doz.	First Grade per Doz.
6	$12.42	$10.80
7	13.50	11.88
8	14.58	12.96
9	16.74	15.12
10	18.90	17.28

The majority of all telegraph shovels and spoons sold are those with 8-ft. handles.

DITCHING AND DRAIN SPADES.

The net prices at Chicago for ditching and drain spades are as follows:

Length of Blade	Extra Grade per Doz.	Third Grade per Doz.
14-in.	$11.34	$8.40
16-in.	11.01	8.70
18-in.	11.88	9.00
20-in.	12.15	....

Skeleton ditching and drain spades made of solid cast steel with solid sockets, especially adapted for mucky and sticky soil, can be bought at the following net prices in Chicago: Ditching spades, square point, 6½x18-in., $22.80 per doz.; drain spades, round point, 4½x18-in., $21.60 per doz. Drain cleaners, with 6½-ft. handles for finishing tile ditches, can be bought at the following net prices:

Size of Blade		
Length (Ins.)	Width (Ins.)	Per Dozen
15	4	$10.80
15	5	11.10
15	6	11.40

STEAM SHOVELS.

(See also Locomotive Cranes, page 410.)

Steam shovels are built weighing as much as 140 tons, but about the most powerful steam shovel regularly built weighs 95 tons. For general work a 5-yard dipper may be used, but for

iron ore or shale an extra heavy one of 2½ or 3½ yards capacity is better. The clear lift from the rail to the bottom of the open dipper door is 16 ft. 6 in. and the maximum width of cut 8 ft. above the rail is 60 ft. This shovel has a record output of four to five thousand yards per day. A steam shovel adapted to extra hard conditions is the 80-ton; the bucket used is generally 3 cubic yards for rock work or 4 yards for earth. The clear lift is 16 ft. and the width of cut 60 ft. A 70-ton shovel is the one most in demand for heavy work under average conditions. It carries a 2 to 3½-yard dipper; the clear lift is 16 ft. 6 in.; width of cut, 60 ft. For work where the depth or amount of excavation is not great enough to warrant a 70-ton shovel a 60-ton is more economical. A 2½-cubic-yard dipper is generally used; clear lift, 15 ft.; width, 54 ft. A 45-ton shovel is designed for use on fairly heavy work, but where lightness and ease of transportation are essential. Capacity of dipper, 2 yards; clear lift, 14 ft.; width of cut, 50 ft. A 40-ton shovel is designed for lighter work or sewer excavation.

The price of steam shovels is as follows:

Weight	Price
120 tons	$14,500.00
95 tons	12,700.00
85 tons	11,250.00
70 tons	9,250.00
60 tons	8,500.00
45 tons	7,000.00
40 tons	6,500.00

Shovels fitted with motors cost from $1,000.00 to $2,500.00 more than steam-driven shovels.

From observations made by the author on half a hundred steam shovels in actual operation during a considerable number of weeks the working capacities shown in Table 149 have been recorded. From these observations the average number of cubic yards per day excavated by all shovels in all materials was 934. This is perhaps less than may be expected on a well-managed job. A shovel should load a dipper 60% full every 20 seconds while actually working. About 50% of the time the shovel is held up by various causes, such as waiting for trains, moving ahead, waiting for blasts, and making repairs. With a 2½-yard dipper a shovel should, therefore, excavate 1,350 cubic yards in 10 hours.

The maximum width of cut given by shovel manufacturers is far greater than the actual average as recorded in observations made by the author. 70 to 95-ton shovels make an average cut of 28½ ft. wide. With a 30 or 40-ton shovel the average cut is not much more than 20 ft. in width.

For low bank work in average earth, where the amount to be excavated is small, 20 to 35-ton shovels, usually fitted with traction wheels, but which can be arranged with railroad trucks, cost as follows:

Shipping Weight	Dipper Capacity	Clear Height of Lift Traction Wheels	R. R. Trucks	Price
22 tons	¾ cu. yd.	12′ 2″	13′ 2″	$4,750
32 tons	1¼ cu. yd.	12′ 8″	13′ 8″	5,600

Shovels of small size usually have vertical boilers.

A 35-ton shovel, with a very high crane which increases the width of cut about 7 ft. and the height of lift about 6 ft., costs $5,800.00. These are regularly equipped with a 1¼-yard dipper.

Revolving steam shovels on traction or railroad wheels (Fig. 283) are as follows:

Size No.	Shipping Weight	Dipper Capacity	Clear Height of Lift Traction Wheels	R. R. Wheels	Price
0	15 tons	½ cu. yd.	8′ 4″	9′	$3,750
1	24 tons	¾ cu. yd.	10′ 6″	11′ 3″	5,000
2	35 tons	1¼ cu. yd.	10′ 6″	11′ 6″	6,000

A No. 1 shovel of the above type was designed for general use on such work as real estate development. For excavating small sewers about 3 ft. wide and 10 to 16 ft. deep a very narrow dipper of ½-cubic-yard capacity and a dipper handle about 30 ft. long are used. In very sandy soil where many shifts from place to place are necessary, and where frequent curves are encountered, this shovel is not a success, according to observations made by the author, but in firm earth where the sewer is long and continuous it is very efficient. 50 to 75 lin. ft. of trench 4 ft. wide and 12 ft. deep have been excavated and back-filled in eight hours by a machine of this type. One runner, one fireman, and two helpers form the crew. Platforms 16 ft. long of 12 x 12-in. timbers are necessary for the shovel to run on. These being built in four sections, each 4½ ft. wide, are carried forward by being hooked to the boom. The cost of such a platform was:

Lumber—168 lin. ft. 12″x12″, 10 lin. ft. 4″x4″ spruce	$104.38
Iron bars, bolts and nuts	6.22
Labor putting together	8.00
Total	$118.60

For excavating cellars the shovel has a standard dipper handle with a ¾-yard bank dipper, and for unloading cars or erecting steel, a crane boom 25 ft. long designed for use with a ½-cubic-yard clam shell or orange peel bucket, or a chain and hook.

Shovel with ½ cu. yd. dipper and 30-ft. dipper handle	$4,550.00
Standard dipper handle and ¾ cu. yd. dipper	500.00
Crane boom without bucket	475.00

A revolving shovel with a horizontal crowding engine, which enables it to excavate very shallow cuts economically, has independent engines for hoisting, swinging and crowding, and a vertical boiler.

Size No.	Shipping Wt. (Tons)	Wt. Equipped (Tons)	Mounting	Dipper Capacity (Cu. Yd.)	Price	Rated Capacity (Cu. Yd.)
0	13	15	Standard	⅝	$3,750	35—40
1	26	30	Gauge or	1	5,500	50—60
Special	20	20	Traction	⅞	4,750	40—50

Mr. Charles R. Gow, in a paper published in the *Journal of the Association of Engineering Societies* for December, 1910, gives some facts and figures concerning the operation of a No. 1 shovel of the above type. This shovel was assembled at the railroad siding and transported about 6½ miles over extremely bad roads. Plank track was necessary and the time occupied was six days. The cost of unloading, assembling and transporting to work was $255.15. The depth of excavation varied from 1 to 17 ft. Part of the ground was fairly easy and the shovel excavated 300 to 500 cubic yards per day, or at the rate of one loaded team per minute while actually working. The

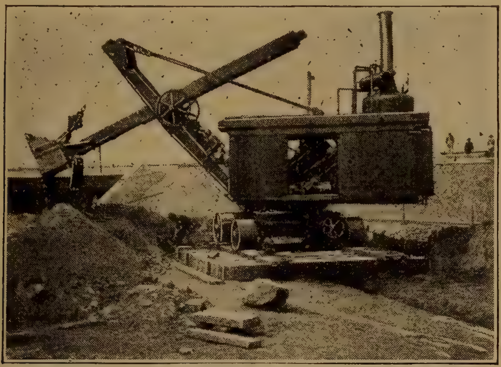

Fig. 283.

remainder of the excavation was in extremely hard ground with many large boulders and a shovel of 60 to 70 tons would have been more economical. The yardage fell to 100 cubic yards per day. In the light cut of 1 to 2 ft. the dipper was crowded 7 ft. horizontally, thus filling it reasonably full.

Cost of steam shovel excavation at Springfield, Mass., 45,081 cubic yards during 191 working days:

	Total	Per Yd.
Cost of delivering and installing shovel....$	495.89	$0.011
Foreman, supervising	1,668.00	.037
Shovel operation, labor	2,118.81	.047
Shovel operation, coal, oil, etc...............	1,487.67	.033
Total cost of operation ....$	3,606.48	$0.080
Repairs, labor	315.57	.007
Repairs, materials	631.14	.014
Total cost of repairs ....$	946.71	$0.021
Depreciation on shovel	1,758.16	.039
Teaming excavated material	9,692.42	.215
General expense, 12.9 per cent..............	2,344.21	.052
Grand total ....$	20,511.86	$0.455

The cost of repairs is exceptionally high on account of the very difficult nature of the work performed. Two new booms were supplied by the makers to take the place of broken ones, the second being of a special design. Several new dipper arms were required and the dipper teeth, chains and ropes were replaced every few weeks.

A No. 1 shovel, working in a cellar excavation about 13 ft. deep, loaded the material, which consisted of pliable clay with a few 12-in. boulders, into cars drawn by a horse along a single track. The costs were as follows:

Wages of engineer	$ 4.00
Wages of fireman	2.00
Wages of one foreman	3.00
Wages of three laborers	5.25
Coal	4.00
Oil, waste, etc.	1.00
Interest, depreciation and repairs (estimated)	5.30
Total	$24.55
Cubic yards per day	410
Cost per cubic yard	.06

45, 60 and 70-ton shovels equipped with dipper handles 45 to 55 ft. long are used for excavating large trenches. A 70-ton shovel was employed in excavating a sewer trench 16 ft. wide by

Fig. 284.

26 ft. deep in Chicago in 1909. (Fig. 284.) This shovel was of the latest design, equipped with a 54-ft. dipper handle and a 2-yard dipper, with the operating levers placed far forward so as to enable the runner to see the bottom of the trench. The

shovel had been removed from its trucks and mounted on a footing, 24 ft. wide by 38 ft. long, of heavy wood beams trussed with steel rods. This platform rested on rollers, which in turn rested on running planks laid on the trench bank. To move the shovel a cable was attached to a dead man and wound up by the shovel engine. The average length of forward move was 15 ft. The shovel moved back 416 ft. in 3½ hours. 569 cubic yards were loaded in a day into 4 and 6-yard narrow gauge cars drawn by 18-ton dinkeys. The crew consisted of 1 engineer, 1 craneman, 1 fireman, and 7 roller men. In addition 6 trimmers, 6 bracers, and 1 foreman were employed on the excavation.

For digging trenches in ground where it would not be safe to support the shovel on the banks, however well sheeted the trench might be, an arrangement which allows the shovel to dig backward is sometimes used. This consists of an extension boom at the end of and in line with the main boom, but slanting downward at an agle of about 45° to the perpendicular. On the lower end of this are placed the crowding engines, reversed from their usual position, thus pointing the dipper mouth towards the shovel. This allows the shovel to remain ahead of the trench on solid ground. A 46-ton shovel equipped in this manner costs $9,000.00.

Where a through cut is being made, the excavation is often too narrow to permit the shovel to turn around and excavate the next cut in an opposite direction, but necessitating the return of the machine backward to the starting point for the next cut. Sometimes this return is 3 or 4 miles long and costs considerable in lost time as well as money. In such a situation the shovel should be equipped with a ball socket, which allows it to be jacked up and revolved on the forward trucks while being held in equilibrium by the weight of the extended bucket and dipper. This equipment costs about $500.00 extra.

Repairs. These depend more on the amount and kind of work done than on the age of the shovel. Repairs are higher for rock work than for earth work, and higher for poorly broken rock than for rock which has been well blasted. Actual total charges for repairs to steam shovels are very difficult to compute, as minor or immediately necessary repairs are made while waiting for trains and during other delays. On most jobs repairs are made at night or on Sundays by the regular crew without extra compensation. Material for repairs to a 65-ton shovel working in a clay pit for 6½ years amounted to an average of $198.00 per year. The maximum amount per year was $375.00 and the minimum $48.00. This does not include the labor charge. Total boiler repairs during the same period cost $200.00. On a 95-ton shovel in rock excavation the boiler was washed and large repairs made once each week by a special crew. This cost about $32.00 per week. Repairs on a 70-ton shovel working in iron ore were made by the regular crew and cost about 50 cts. a day. During the 6 months ending June 30, 1910, the cost of repairs to steam shovels on the Panama Canal work averaged $27.66 per day per shovel for 9,527 days' service.

Col. Goethals, chief engineer of the Panama Canal, has been kind enough to furnish me with the following information as to steam shovels on that work up to and including the fiscal year 1908. There were then in service 101 shovels, one 20-ton, ten 45-ton, seven 60-ton, thirty-five 70-ton, sixteen 91-ton, and thirty-two 95-ton shovels, which cost a total of $1,094,367.00.

The cost of repairs was as follows:

Fiscal Year Ending	No. of Steam Shovels in Service	Cost of Steam Shovel Repairs	No. of Yards Steam Shovel Excavation	Cost of Steam Shovel Repairs per Cu. Yd.
June 30, 1906........	41	$ 20,337.89	1,506,562	$0.0135
June 30, 1907........	63	209,244.48	6,215,771	.0337
June 30, 1908........	101	479,607.16	17,467,061	.0275
Total	205	$709,607.53	25,189,394	$0.02815

These repairs were accomplished under peculiarly expensive conditions:

1. Wages over 50% higher than in the United States.
2. Cost of privileges granted employes.
3. Unusually difficult excavation.
4. High cost of material.

All steam shovels were given such field repairs as were necessary.

Depreciation. The regular life of a steam shovel is about 20 years, the cost new is about $200.00 per ton and the scrap value about $10.00 per ton. Depreciation per year, by the straight line formula, would therefore be 4.75%.

The size of shovel for any given work should depend upon the yardage in each cut, not upon the total yardage of the contract. It depends also upon the distance and the character of the ground over which the shovel has to be moved and the number of moves to be made. Use a 26-ton shovel for small cuts where moves will be frequent, a 55 to 65-ton where cuts are heavy and moves not frequent, and the largest available one where the cuts are very long and deep.

The cost of moving a shovel varies greatly with the conditions. In certain railroad excavation it took 4 weeks with a full crew to move a 65-ton shovel 6 miles, and 3 weeks to move down across a valley from the finished cut to a new cut, a distance of ¼ mile. The cost of moving a 65-ton shovel 1 mile on a country road with heavy grades, and ½ mile through fields with a 15° slope, was $316. It took 8 days, involving the services of 1 shovel crew, 1 team, 1 foreman, and 8 men. A 35-ton traction shovel has been moved 18 miles in 18 days by its crew, whose wages amounted to $35 per day, 17 miles being over rough roads and 1 mile being across fields and up hill.

Shovels may be rented for $250 to $400 per month, according to size and condition.

TABLE 149.—CUBIC YARDS EXCAVATED PER DAY IN VARIOUS MATERIALS WITH VARIOUS SIZED SHOVELS.

Size of Shovel (Tons)	Iron Ore				Sand & Gravel				Earth & Glacial Drift				Rock				Clay				Average			
	No. of Shovels Observed	Yds. per Day			No. of Shovels Observed	Yds. per Day			No. of Shovels Observed	Yds. per Day			No. of Shovels Observed	Yds. per Day			No. of Shovels Observed	Yds. per Day			No. of Shovels Observed	Yds. per Day		
		Min.	Ave.	Max.		Min.	Ave.	Max.		Min.	Ave.	Max.		Min.	Ave.	Max.		Min.	Ave.	Max.		Min.	Ave.	Max.
45	..	....	....	....	2	360	366	373	..	....	....	....	..	...	...	....	..	...	....	....	2	360	366	373
55	..	....	....	....	..	....	....	....	..	....	....	....	..	...	...	....	1	320	320	320	1	320	320	320
65	..	....	....	....	..	....	....	....	1	1,065	1,065	1,065	5	264	601	896	2	474	627	780	8	264	665	1,065
70	7	892	1,095	1,512	3	1,602	2,365	3,300	3	569	893	1,426	16	168	682	1,542	5	498	1,064	1,450	34	168	991	3,300
75	..	....	....	....	..	....	....	....	..	....	....	....	..	...	...	....	1	820	820	820	1	820	820	820
90	1	2,728	2,728	2,728	..	....	....	....	..	....	....	....	..	...	...	....	..	...	....	....	1	2,728	2,728	2,728
95	1	1,350	1,350	1,350	..	....	....	....	1	1,073	1,073	1,073	5	154	873	1,200	1	990	990	990	8	154	972	1,350
Average	9	892	1,305	2,728	5	360	1,566	3.300	5	569	963	1,426	26	154	704	1,542	10	320	870	1.450	55	168	934	3,300

POWER CONSUMPTION OF ELECTRIC SHOVEL.

An electric shovel with a 2½-cubic-yard dipper was used in excavating gravel for the Carson River dam at Lahontan, Nev. The line voltage was 2,300, which was stepped down to 440 by three 90 K. V. A. single-phase transformers located on the shovel. These transformers were connected to the distributing

Fig. 285.

system by 700 ft. of triple-covered flexible cable armored with D-shaped steel tape, which was dragged along the ground as the shovel moved. This cable was dragged over rocks and through mud and water, but required very little protection. The hoisting machinery was driven by a 115-hp., 440-volt, three phase, 60-cycle, variable-speed induction motor. The propelling machinery

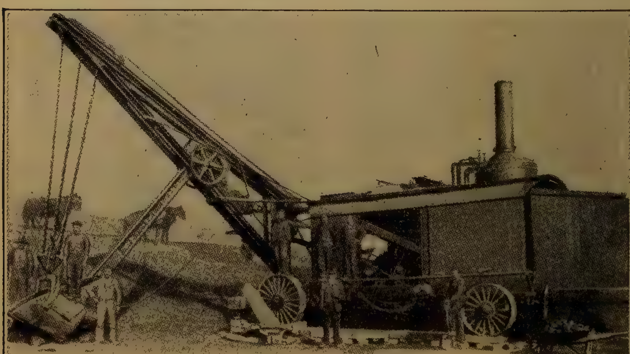

Fig. 286. Little Giant High Crane Steam Shovel, 35 Tons, 1¼ Cubic Yard Dipper.

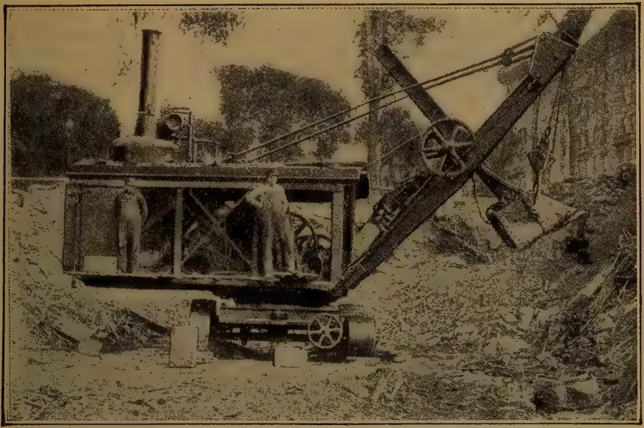

Fig. 287. No. 1 Revolving Shovel Excavating Cellars.

Fig. 288.

was also driven by this motor. The swinging machinery was geared to a 50 hp. motor, and the thrust motor was also 50-hp. The compressor which furnished air to the hoisting drum brake, the emergency brake on the swing motor, and the friction clutch and brake on the intermediate shaft were driven by a 2-hp. constant speed induction motor.

A test made on October 14, 1912, when the shovel was working in a gravel bank 10 to 12 ft. high, with a clear lift of dipper of 16 ft., loading 6-car trains, gave the following results:

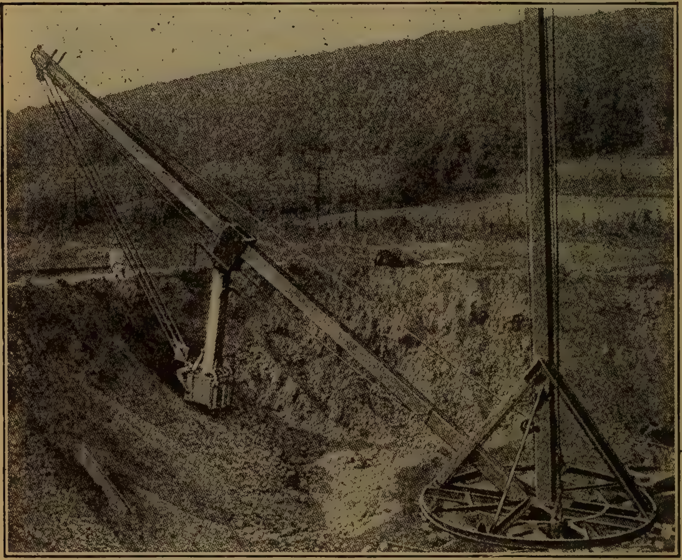

Fig. 289. View Showing Excavator Digging.

Total time observed, 45.5 minutes.

Digging and loading occupied 57% of the time. Delays, moving up, etc., occupied 43% of the time. Rate of digging on observed basis, 1,500 cubic yards of loose gravel in 8 hours. Total power consumed by shovel in 8 hours, 453 kw. hours = 0.302 kw. hours per cubic yard of loose gravel.

Figs. 285-287 illustrate several makes of shovels in operation on different classes of excavation.

DERRICK EXCAVATOR.

A recent addition to the large number of excavators is the Bishop Derrick Excavator (Figs. 288-289).

The properties of this machine furnished by the manufacturer are as follows:

TABLE 150.—DERRICK EXCAVATORS.

Cap. in Cubic Yards	Size of Boom Standard Carriage is Built for Inches	Wt. of Carriage, Pounds	Wt. of Shovel, Pounds	Av. Length of Boom, Feet	Av. Length of Mast, Feet	Hoisting Engine, Double Cylinder, Double Drum and Swing Gear: Cylinder	Hoisting Engine, Double Cylinder, Double Drum and Swing Gear: Boiler, Horsepower	Plow Steel Gripping Cable, Diam.
½	12x12 and 12x14	925	1875	30-60	35-65	7 x10	20	1 inch
⅝	14x14 and 14x16	975	2000	35-55	40-60	7 x10	30	1 inch
⅞	14x14 reinforced and 14x16	1050	2845	35-50	40-65	8¼x10	30	1 inch
1	14x16 and 14x18	1125	3200	35-50	40-65	8¼x10	30	1 inch

Carriages can be made for any size of booms, other than specified above.

The length of dipper stick is governed by the depth of digging; if digging is to be done at a considerable depth below base of derrick, the dipper stick must be lengthened accordingly.

The changing of the carriage, for example, from a 12 x 12 to a 12 x 14 boom, or vice versa, is accomplished by simply shifting two angles held by a number of bolts.

The prices of the above, f. o. b. New York, including carriage with all attachments ready to be fitted to the boom of a derrick, manganese steel teeth, and gripping cable, but not including wooden dipper arm, are as follows:

½ cu. yd. capacity	$ 800.00
⅝ cu. yd. capacity	900.00
⅞ cu. yd. capacity	1,000.00
1 cu. yd. capacity	1,050.00

STEEL

Structural Shapes. The following prices were abstracted from *Engineering and Contracting.* They are subject to considerable variation with the market.

Structural shapes f. o. b. Pittsburgh:

I-beams and channels, 3 to 15 in., 1.50 to 1.55 cts. net.
I-beams over 15 in., 1.65 cts. net.
H-beams over 8 in., 1.75 cts.
Angles, 3 to 6 in., 1.60 cts.
Angles over 6 in., 1.65 cts.
Tees, 3 in. and up, 1.65 cts.
Zees, 3 in. and up, 1.60 cts. net.
Angles, channels and tees under 3 in., 1.50 cts., base, plus 10 cts.
Deck beams and bulb angles, 1.80 cts. net.
Hand rail tees, 2.80 cts. net.
Checkered and corrugated plates, 2.80 cts. net.

Prices at Chicago for shipment from stock are as follows:

Angles, 3 to 6 in.	2.00
Angles over 6 in.	2.10
Beams and channels	2.00
Beams over 15 in.	2.10

The New York quotations for structural shapes are as follows:

Beams and channels, 3 to 15 in.	1.66@1.71
Zees, 8 in. and up	1.76@....
Angles, 3x3 up to 6x6	1.66@1.71
Tees	1.81@....
Steel bars, full extras	1.71@1.76

Plates. The corresponding prices for plates f. o. b. Pittsburgh on the basis of net cash in 30 days are as follows:

Tank plates, ¾ in. thick, 6¼ in. up to 100 in. wide, 1.55 cts. to 1.60 cts. base.

Gages under ¼ in. to and including $\frac{3}{16}$ in.	$0.10
Gages under $\frac{3}{16}$ in. to and including No. 8	.15
Gages under No. 8 to and including No. 9	.25
Gages under No. 9 to and including No. 10	.30
Gages under No. 10 to and including No. 12	.40
Sketches, 3 ft. and over in length	.10
Complete circles, 3 ft. diameter and over	.20
Boiler and flange steel	.10
A. B. M. A. and ordinary fire box steel	.20
Still bottom steel	.30
Marine steel	.40
Locomotive fire box steel	.50
Plates in widths over 100 in. to 110 in.	.05
Plates in widths over 110 in. to 115 in.	.10
Plates in widths over 115 in. to 120 in.	.15
Plates in widths over 120 in. to 125 in.	.25
Plates in widths over 125 in. to 130 in.	.50
In widths over 130 in.	1.00

Prices at Chicago for shipment from stock are as follows:

¼ in. and heavier, up to 72 in.	$2.00
Over 72 in.	2.10
$\frac{3}{16}$ in. thick	2.10
No. 8	2.15

The following were the New York quotations on plates, the prices being based on carload lots, with 5 cts. extra for less than carload lots. Terms, net cash in 30 days, per 100 lbs.:

Tank plates, ¾ in. thick, 6½ to 100 in. wide	$1.71@1.76
Tank plates, ¾ in. thick, 6½ to 100 in. wide	1.71@1.76
Flange and boiler steel	1.81@1.86
Marine	2.11@2.16
Locomotive and fire box	2.21@2.26
Still bottom	2.01@2.06

Plates more than 100 in. in width, 5 cts. extra per 100 lbs.; plates $\frac{3}{16}$ in. in thickness, 10 cts. extra; gage Nos. 7 and 8, 15 cts. extra; No. 9, 25 cts. extra.

Sheets. The corresponding minimum prices for mill shipments from Pittsburgh on sheets in carload and larger lots are as follows:

Galvanized roofing sheets No. 28, 2½ in. corrugations, per square	$3.00
Painted roofing sheets, No. 28, per square	1.70

Galvanized Sheets:	Per Lb.
Nos. 13 and 14	2.50 cts.
Nos. 15 and 16	2.60 cts.
Nos. 17 to 21	2.75 cts.
Nos. 22 to 24	2.90 cts.
Nos. 25 and 26	3.10 cts.
No. 27	3.30 cts.
No. 28	3.50 cts.
No. 29	3.60 cts.
No. 30	3.85 cts.
Black Annealed Sheets:	
Nos. 3 to 8	1.70 cts.
Nos. 9 and 10	1.75 cts.
Nos. 11 and 12	1.80 cts.
Nos. 13 and 14	1.85 cts.
Nos. 15 and 16	1.90 cts.
Box Annealed Sheets:	
Nos. 17 to 21	2.20 cts.
Nos. 22 to 24	2.25 cts.
Nos. 25 and 26	2.30 cts.
No. 27	2.35 cts.
No. 28	2.40 cts.
No. 29	2.45 cts.
No. 30	2.55 cts.

Prices for sheets at Chicago for shipment from stock are as follows:

	Cts. per Lb.	
	Black	Galvanized
No. 10	2.25	3.20
No. 12	2.30	3.20
No. 14	2.35	3.20
No. 16	2.45	3.20
Nos. 18 and 20	2.80	3.35
Nos. 22 and 24	2.85	3.50
No. 26	2.90	3.70
No. 27	2.95	3.90
No. 28	3.00	4.10
No. 30	3.30	4.50

Usual extras for extreme width.

The following New York quotations on sheets are for 500-bundle lots and over, f. o. b. mill:

Gage	Cts. per. Lb. Black	Galvanized
No. 30	2.55	3.85
No. 29	2.45	3.60
No. 28	2.40	3.50
No. 27	2.35	3.30
Nos. 25 to 26	2.30	3.10
Nos. 22 to 24	2.25	2.90

Freight Rates. The freight rates from Pittsburgh on finished iron and steel in car loads, per 100 lbs., were as follows: Birmingham, Ala., 45 cts.; Boston, 18 cts.; Buffalo, 11 cts.; Chicago, 18 cts.; Cincinnati, 15 cts.; Cleveland, 10 cts.; Indianapolis, 17 cts.; New York, 16 cts.; New Orleans, 30 cts.; Philadelphia, 15 cts.; St. Louis, 23 cts.; St. Paul, 32 cts. For the Pacific Coast the rates are 80 cts. on plates, structural shapes and sheets No. 11 and heavier; 85 cts. on sheets Nos. 12 to 16; 95 cts. on sheets No. 16 and lighter, and 65 cts. on wrought pipe and boiler tubes.

Corrugated Roofing. The following quotations on corrugated roofing are for small lots:

2½ In. Corrugated	Painted	Galvanized
No. 24, per 100 sq. ft.	$3.85	$4.80
No. 26, per 100 sq. ft.	2.95	4.00
No. 28, per 100 sq. ft.	2.60	3.75

BRIDGE BUILDERS' AND STRUCTURAL STEEL ERECTORS' SPECIAL TOOLS.

The following prices are net prices in Chicago, for quantities, for special tools for bridge builders and structural steel erectors:

	Weight, Pounds	Face, Inches	Length, Inches	Price, Each
Riveting hammers	4	1½ and 1⅜	8½	$1.25
Flogging hammers	7	1¾	7	1.50
Napping hammers	3	1⅛	6	1.00
Rivet "buster"	5½	1½ in. sq.	6	.80
Straight blade cold cutter	...	1¼ in. sq.	6½	.80
Cross blade cold cutter	...	1½ in. sq.	6½	.80
Side set or cutter	...	1½ in. sq.	6½	.80
Handle gouge	...	1½ in. sq.	6½	.85

The net prices of other tools used by bridge builders and structural steel erectors are as follows:

	Price, Each
Straight dolly	$2.75
Club dolly	3.25
Spring dolly	5.00
Heel dolly	4.50
Half round seamers	.65
Hand gauges	.25 to .35
Hand chisels	.35
Rivet tongs, pickup at heating, per pair	.70
Riveting clamp	3.75

Rivet snaps or sets for button head or conical head rivets cost as follows:

¾ in. to ⅝ in., each	$1.20
¾ in., each	1.25
⅞ in., each	1.40
1 in., each	1.50

The net cost of barrel shaped drift pins follow:

7/10 in., each	$0.10
9/16 in., each	.11
11/16 in., each	.12
13/16 in., each	.16
15/16 in., each	.17
1 1/16 in., each	.19

The net cost figures for heading out punches are as follows:

⅜ in. to ¾ in. inclusive, each	$0.80
⅞ in. to 1 in. inclusive, each	.85

STONE BOATS

Mr. H. P. Gillette says: "A team of horses can exert a pull of 1,000 lbs. for a short time if they have a good earth foothold. The sliding friction of iron or wood on earth is about 50 per cent of the weight of the load that is being dragged, hence a team is capable of dragging a stone boat and load together weighing 2,000 lbs." If a "skid road" of partly buried timber is built and kept well greased a stone boat can be hauled with extreme ease. A weight heavier than a wagon load can be pulled. Stone boats 3′ wide, 7′ long with three 4″x4″ timber runners curved up in front and shod with iron, and a 2″ plank floor have been made on jobs in the vicinity of New York from 1907 to 1910 costing $15 to $20. They last about one season under hard work with one reshoeing which costs 50 per cent of the original cost.

Stone boats 2′ wide and 5′ long of three 2″x8″ planks bent up in front, but not shod with iron cost $7.50.

Stone boats with a timber frame and a steel bottom cost as follows:

No.	Length	Width	Weight	Price
1	72 in.	28 in.	130 lbs.	$6.50
2	88 in.	30 in.	160 lbs.	7.50

STUCCO MACHINES

By means of this machine stucco may be applied to buildings, etc., with various finishes, somewhat more cheaply than by hand. It consists of a "plastic material hopper" in which the mixture is placed, and from the bottom of which it is drawn. Upon a shaft, parallel with the bottom opening of the hopper, is operated a cylinder upon the surface of which are a great number of spring spokes. By special construction of the bottom of the hopper directly under the hub the springs are caused to snap and throw the cement aggregate against the wall. The hub is revolved by means of gears operated by hand or other power. On the "upright machines" the hopper is raised and loaded on a frame. The lower uprights are made in 14 ft. lengths, the upper in 10 ft. lengths, one upright of each size being furnished.

TABLE 151.—DIMENSIONS AND PRICES OF STUCCO MACHINES.

	Width of Cylinder	Size of Hopper	Capacity of Hopper	Size of Platform	Width Cylinder with Cover	Price f. o. b. N. Y.
Hand machine	6 in.	7x11x15	¾ cu. ft.	...	6 in.	$100.00
12 in. upright machine	12 in.	13x13x20	2 cu. ft.	4x5	12 in.	275.00
18 in. upright machine	18 in.	18x21x25	5½ cu. ft.	6x7	18 in.	350.00
18 in. upright power machine	18 in.	18x21x25	5½ cu. ft.	6x8	18 in.	500.00

STUMP PULLERS

There are four methods of grubbing: By hand, by burning, by blasting, and with a stump pulling machine. An axe, a mattock, a round pointed shovel, and a long heavy pole for use as a lever are the tools required in the first method. If trenches are dug around the stumps in the fall of the year, the frost will aid materially in heaving the stumps.

On land that has been cut over previously, leaving the stumps wholly or partially dead, burning is sometimes economical. Where the stumps are green, they must be removed from the ground and dried before they will burn.

By far the best method of grubbing is by blasting, if properly done. A ship augur 1 or 1¼ inches in diameter, costing $1 to $1.25 should be used to bore a hole near the base of the stump. For small stumps dynamite should be used exclusively. The hole in large stumps should first be sprung with a small charge of dynamite, and then blown with Judson or black powder.

Mrs. Edith Loring Fullerton in "The Lure of the Land" gives the following account of means used in grubbing and clearing the land of the Long Island Experiment Farm: "Small stumps up to four feet require about ½ lb., while large ones, say, six to eight feet in diameter, require 3 lbs. of the explosive which is placed in several separate holes surrounding the stump. . . .

"Fourteen fuse charges are placed under as many stumps; the method of placing, by the way, is to lower the charge into the oblique hole, press it steadily and firmly with a blunt ended stick until expanded to the full size of the crowbar hole, then fill up the hole with earth and tramp it firmly, that no explosive gases may find a loophole of escape. . . .

"Dynamiter Kissam, with 'Dell' Hawkins' assistance, blew regularly from 75 to 110 stumps a day. The dynamite splits them so completely that they can be burned at once. The stumps taken out by hand required cleaning, splitting and drying before they could be burned; an added expense. Below are the comparative figures on 100 stumps:

DYNAMITE.

Average 60 lbs. dynamite at 15c per lb.	$ 9.00
Labor of expert and helper	5.50
100 fuses at 45c per 100 feet	.75
100 caps at 75c per 100	.75
Total	$ 16.00

HAND LABOR.

100 average stumps require 3 men 33 days at $1.33 per day.. 131.67

"Stump pullers were out of the question, there was no standing timber for the block and fall to be fastened to, the time nec-

essary to hitch to stumps buried just under the surface, frequently with rotted heart, together with the cost of the puller, hire of horses and men, made it way beyond the power of competing with dynamite."

Where there are a number of large stumps or trees to act as dead men, the use of stump pulling machines is economical. Figs. 290-291. Where there are no natural dead men, the

Fig. 290.

Fig. 291.

machine must be anchored by means of large butts driven in the ground.

Stumps are pulled with a direct pull, the cable running from the stump to the machine, or with a double pull, the cable running through a block fastened to the stump and being attached to another dead man.

A long cable should be used, as the machine is then moved fewer times. A 60-foot cable will clear about ¼ acre, an 85-foot cable about ½ acre, a 100-foot cable ¾ acre, a 150-foot cable 1½ acres, a 200-foot cable nearly three acres, from one set-up.

There are many types and makes of stump pullers on the market. The one illustrated in Fig. 291 is an improved machine constructed of steel and iron with the exception of the lever, which is a pole 12 to 25 feet long, cut from the woods.

A one-horse operated machine suitable for pulling trees and

stumps up to 8″ in diameter, fitted with 2 steel double power pulleys and 100 feet of ⅝″ cable, weighs 490 lbs., and costs $40.

A two-horse machine with a listed capacity of 22 tons, with 100 ft of ¾″ cable, weighs 475 lbs., and costs $35. The same outfit with one steel double power pulley has a capacity of 44 tons, weighs 535 lbs., and costs $45; with two pulleys it has a capacity of 66 tons, weighs 595 lbs., and costs $50.

A machine with a capacity of 30 tons, with 210 feet of ¾-inch cable, weighs 775 lbs., and costs $85; with 1 pulley, having a capacity of 60 tons, weighs 855 lbs., and costs $90; with 2 pulleys, having a capacity of 90 tons, weighs 930 lbs., and costs $110.

The pullers having 50, 100 and 150 ton capacities with the outfits heretofore described, weigh respectively 1,160, 1,260 and 1,360 lbs., and cost $120, $145 and $155.

The capacities and prices of the largest machines are as follows:

Capacity 63 tons, with 100 feet 1⅛-inch cable, weight 1,450 lbs, price $145; with 200 feet cable, weight 1,650 lbs., price $200.

Capacity 125 tons, with 1 pulley, 100 feet 1⅛-inch cable, weight 1,600 lbs., price $175; with 200 feet of cable, weight 1,800 lbs., $225.

Capacity 185 tons, 2 pulleys, 120 feet 1⅛-inch cable, weight 1,750 lbs., price $200; with 220 feet of cable, weight 1,950 lbs., price $255.

For taking up the slack rope, cam take-ups are used. These cost from $4.50 to $25. Root and stump hooks cost from $7 to $12.

The largest sizes of these machines are often used to move houses and buildings.

SURVEYING AND ENGINEERING EQUIPMENT

DRAWING INSTRUMENTS

(See Levels, Drawing Boards and Transits)

	Price	Weight
1 beam compass............$6.00 to	$12.20	2 oz. each
1 dotting pen............... 0.80 to	6.80	1 oz. each
1 railroad pen.............. 2.00 to	3.00	1 oz. each
1 set drawing instruments...........	6.16 up	16 oz. each
2 German silver protractors { 4"......	1.35	2 oz. each
{ 6"......	3.15	
2 engineers' triangular scales, 12"...	1.20 each	1 oz. each
2 archeticts' triangular scales, 12"...	2.00 "	1 oz. each
2 45° triangles { 6".................	.36 "	1 oz. each
{ 10".................	.76 "	
2 30-60 . { 6".......................	.24 "	1 oz. each
{ 10".......................	.52 "	
1 set R. R. curves..................	6.98 11.93	5 lbs. each
1 set French curves.................	9.26	5 lbs. each
2 T squares { 36"..................	.44	8 oz. each
{ 36"..................	.84	5 lbs. each
{ 30"x42"...............	13.05	
1 blue print frame..................		
1 plan case.........................	18.00	50 lbs. each
Thumb tacks	1.28	1 lb. each
Water colors, 20 colors @ $0.18 a pan	3.60	1 lb. each
Higgins Inks, 16 colors @ $0.25 a bot.	4.00	1 lb. each
Rail gauges........................		5 lbs. each
1 current meter.....................	45.50	5 lbs. each
2 leveling rods, Philadelphia.........	13.50 each	5 lbs. each
2 Florida rods, 12-ft.................	9.00 "	3 lbs. each
3 range poles, 10-ft..................	2.25 "	3 lbs. each
3 plumb bobs	1.80 "	¾ lb. each
Stake tacks........................	1.35	5 lbs. each
2 tape mending tools.................	3.60	1 lb. each
2 steel tapes, 100-ft.................	10.32	2 lbs. each
2 steel tapes, 50-ft..................	6.00	1 lb. each
1 cloth tape, 100-ft..................	3.28	1 lb. each
1 planimeter	25.20	1 lb. each
1 pantograph	4.50	1 lb. each

TAMPERS

Net Prices. The net prices for tampers with handles are as follows, No. 1 having steel plate base, No. 2 a cast plate base and No. 3 a round cast plate base:

No.	Size Base (Ins.)	Weight Finished	Price Each	Price per Doz.
1	8 x 8	13	$1.50	$15.00
1	10 x10	16	1.65	16.50
1	12 x12	26	1.80	18.00
2	5 x 6	9	.78	7.80
2	6 x 7	13	.01	9.10
2	7 x 8	14	.98	9.80
2	8 x 8	15	1.04	10.40
2	10 x10	20	1.25	12.50
2	5 x 6	24	1.43	14.30
3	7	20	1.50	15.00
Curb	1 x 3½	3	.62	6.20
Curb	4 x 4	5½	.78	7.80
Curb	3½x 6	6½	.82	8.20
Comb. curb	1 x 3½	8½	1.50	15.00

The above prices are for tampers with wooden handles.

Paving Rammers. Net prices at Chicago for paving rammers are as follows:

Kind	Weight (Lbs.)	Price, Each
Granite rammer	56	$10.00
Cobblestone rammer	50	8.00

A Power Tamping Machine, Fig. 292, consists of a two-wheeled truck on the rear end of which is an air-cooled gasoline engine, battery box and gasoline tank, which drives by a belt a hardwood "lifting board" with a cast iron head. This tamper is lifted by the power engine and allowed to fall by gravity. Only one

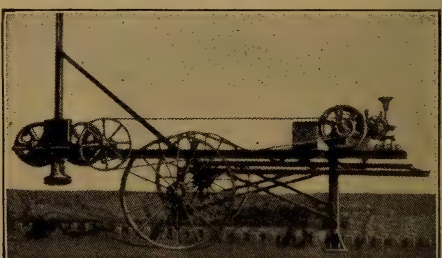

Fig. 292. Power Tamping Machine.

man is necessary to operate the machine, and the manufacturer claims that it will strike 60 blows per minute or 28,800 per eight hour day. On this basis and allowing 50 per cent for lost time and wasted strokes, the head, the area of which is ½ sq. ft., will

cover 7,200 square feet in one day, or in a trench 3 feet wide and 5 feet deep, tamped in 6-inch layers, will cover 240 lineal feet of trench. It is claimed that the machine will do the work of five or six men. The standard machine will strike in a trench from 1 to 4½ ft. wide from 6 ft. in depth to the surface. Length of stroke, 2 ft.; weight of tamper, 85 lbs.; size of head, 8"x9"; 1 H. P. gasoline engine consuming 1½ gallons of gasoline in ten hours; wheels, 4"x36" steel; net weight, 950 lbs.; shipping weight, 1,200 lbs.; price, $300.

Compressed-Air Driven Rammers, Fig. 293, for use in foundries are comparatively a recent innovation, but from their simple

Fig. 293. Chicago and Keller Rammers at Work on Sewer Covers.

construction and the large amount of work they will accomplish are being rapidly adopted. Owing to their lessening the manual efforts of the moulder, they enable him to accomplish from four to twelve times as much work as under old hand methods. These rammers are especially adapted for the manufacture of concrete building blocks, pier foundation blocks, sewer covers, chimney caps, window sills, curbing, etc. The prices of the following rammers are as follows:

Size (Ins.)	Used for—	Air Used per Min. (Cu. Ft.)	Wt. (Lbs.)	Blows per Min.	Air Pressure (Lbs.)	Price
⅞x 4	Bench work and cores	9	7	600 to 800	60 to 80	$0.60
1 1/16x 7	General foundry and concrete work......	15	18	400 to 550	60 to 80	.60
1¼x 7	General floor work...	20	24	300 to 450	60 to 80	.60
3 x10	Pit and loam work...	25	280	250 to 300	70 to 90	1.50

TELEPHONES AND TELEPHONE LINES

COST OF A CONSTRUCTION SERVICE TELEPHONE LINE IN CUBA.

Specifications: Length 15 miles, 464 poles, line is 2-wire metallic circuit No. 12 B. & S. gage, hard drawn copper wire, oak brackets, glass insulators, poles spaced 171 feet apart.

	Per Mile
Digging holes	$ 32.71
Squaring poles, etc	14.19
Setting poles	135.65
Stringing wire	78.73
Tools	2.86
General	4.45
Total	$268.59

A simple system a mile or so in length, suitable for contractors, costs $11.00 for each instrument complete with batteries and lightning arrester; about $7.00 per mile for G. I. wire and about $3.00 per mile for insulators. This is for a ground return line.

A double metallic circuit system costs $8.70 for each instrument fitted with magneto, 1,000 ohm ringer and 3-bar generator; about $14.00 for wire and $3.00 for insulators per mile.

Neither of the above lines includes costs for poles or erection.

The following costs have been compiled from an article in *Engineering and Contracting* on the cost of building a high power transmission line. The average length of haul was one mile. The wages paid per 10-hour day were:

Foreman	$3.00
Laborers	1.50
Linemen	2.50
Team, 2 horses and driver	4.50

The poles were of chestnut 30 to 33 ft. long, 5 to 9 inches at the top, and 12 to 18 inches at the bottom. Seventy-four poles, 8 to 10 on a load, were unloaded from cars and hauled to the work for $30. Seventy-four holes, 5 ft. deep and an average of 24 inches in diameter were dug at a cost of $72.75 or 98 cents per hole. Poles were raised by hand at a cost of $56.75 or 76 cents per pole, and were dapped for the cross arms at a cost of $22.62 or 9.8 cents per dap. One hundred and sixty-six cross arms, well braced, were placed at a cost of $27.62 or 17 cents per cross arm. Nine hundred and ninety-six insulators were placed at a cost of $6 or 0.6 cents per unit.

At all the turns the poles were guyed, and elsewhere where necessary. The cost of digging the holes for this was $8.25 or 92 cents per hole. Raising the poles cost $12, and guying them $9, or a total of $3.25 per guy pole. In some places trees and bushes interfered with the work and these were cut down for $33.50.

Twelve light wires were strung on each pole at a cost of $118.50 for 21.6 miles or for $5.50 per mile of wire. Where the line was connected with the old line 4 poles had to be changed, which cost $56.50 or $14.12 per pole.

The cost of the entire 1.6 miles of line was:

Item	Total Cost	Per Mile
Hauling	$ 30.00	$ 18.74
Digging holes	72.75	45.47
Raising poles	56.75	35.47
Dapping cross arms	22.62	14.14
Placing cross arms and insulators	33.62	21.01
Guy poles	29.25	18.28
Trimming trees and bushes	33.50	20.94
Stringing wires	118.50	74.06
Changing old poles	56.50	35.31
Total	$453.49	$283.42

The following itemized cost of two telephone lines is taken from *Engineering and Contracting.*

Two short lines were built, one 10 miles long and the other 14 miles long. The cost of the 10 mile line was as follows per mile:

LABOR.

1.7 days foreman at $4.00	$ 6.80
1.7 days sub-foreman at $3.00	5.10
4.0 days climbers at $2.50	10.00
10.5 days groundmen at $2.25	23.63
17.9 days total at $2.54	$45.53

MATERIALS.

28 poles at $1.50	$42.00
28 cross arms at $0.15	4.20
28 steel pins at $0.04	1.12
28 glass insulators at $0.04	1.12
56 lag screws and washers at $0.015	.84
305 lbs. No. 9 galvanized wire at $0.042	12.81
Total	$62.09

Total labor and materials, $107.62 @ $10.76 per mile.

More than 90 per cent of the poles were 25 feet long. The rest were 30 to 40 feet in length.

The cost of the 14 mile line was as follows, per mile:

LABOR.

2.2 days foreman at $3.50	$ 7.70
2.2 days sub-foreman at $3.00	6.60
5.3 days climber at $2.75	14.58
11.4 days groundman at $2.25	25.64
21.5 days total at $2.54	$54.52

MATERIALS.

32 poles at $1.50	$ 48.00
32 brackets at $0.015	.48
380 lbs. No. 8 galvanized wire at $0.042	15.96
10 lbs. No. 9 galvanized wire at $0.042	.42
1½ lbs. fence staples at $0.025	.04
32 insulators at $0.04	1.28
Total	$ 66.18
Total labor and materials	120.70
2 telephones at $12.50	25.00
200 ft. office wire	1.40
Total	$213.28 @ $15.24 per mile

Considering the low cost of telephone lines of this character, it is surprising that they are not more frequently built for use on construction work. For temporary purposes, a much cheaper kind of pole could be used. For example, a very substantial pole can be made by nailing together two 1x4-in. boards, so as to form a post having a T-shape cross-section. Such a pole would contain only two-thirds of a foot, board measure per lineal foot of pole. At $24 per M for the boards, a pole 20 ft. long would cost 32 cents. Hence the poles would cost less than $10 per mile of line. The No. 9 wire would ordinarily cost less than $13 per mile, and $3 more would cover the cost of the remaining line materials, making a total cost of $26 per mile for materials. I have no data as to the labor of erecting such a line, but it would certainly be less than $15 per mile; and in soil where post hole diggers could be used, the cost would be considerably less. In fact, a telephone line built for $35 a mile might easily be obtained under fairly favorable conditions. Moreover, it could be taken down and used many times on subsequent construction.

TELEPHONE POLE TOOLS.

	Length (Ft.)	Weight (Lbs.)	Price Each
Steel digging bars	8	28	$ 2.30
Steel digging and crow bars	8	28	2.75
Steel digging and tamping bars	8	30	2.50
Pipe poles	12 to 20		$8.40 to 11.70
Raising forks	12 to 20		6.00 to 9.00
Wood handle tamping bars	8		1.00

Poles. Cedar poles are (1911) quoted as follows by the R. D. Dowie Pole Co., 432 New York Block, Seattle, Wash. The price is f. o. b. loading point:

Length in Ft.	Price Each Diameter at Top 8-in.	9-in.
30	$2.70	....
35	3.15	$ 3.50
40	3.60	4.00
45	....	4.50
50	....	5.00
55	....	5.50
60	....	7.20
65	....	9.75
70	....	10.50
75	....	11.25
80	....	12.00

White cedar poles are quoted (1911) by the Backus-Judd Lumber & Cooperage Co., Minneapolis, Minn., f. o. b. Rex, Mich., freight rate to Chicago 12 cents, as follows:

Length in Ft.	Price Each Diameter at Top 5-in.	6-in.	7-in.
25	$0.65	$ 1.00	$ 1.50
30	....	1.60	3.75
35	....	4.00	5.00
40	....	5.25	7.00
45	....	7.25	9.50
50	....	10.00	11.00

Chestnut poles, f. o. b. Mechanicsville, N. Y., are quoted (1911) by T. C. Luther of that place as follows:

Length in Ft.	Price Each Diameter at Top 5-in.	6-in.	7-in.
25	$1.50	$2.00	$2.75
30	2.50	2.75	3.25
35	2.75	3.25	4.00
40	3.25	4.00	5.50
45	4.00	5.50	7.50
50	5.50	7.50	9.50

Fir Cross Arms. Prices are about as follows:

Length Size, 3¼x4¼ in.	Price per Arm in Cts. Pacific Coast	Chicago	New York
3 ft., 2 pin	8	13½	15½
4 ft., 2 pin	11	18½	21
5 ft., 4 pin	16	26½	28½
6 ft., 4 and 6 pin	20½	31½	36
8 ft., 6 and 8 pin	28	43	48½
10 ft., 8, 10 and 12 pin	37	55½	67½

Telegraph Wire. For lots of fair size, the wire measured in Birmingham wire gage, the prices in cents per lb. are about as follows: "Extra Best Best," Nos. 6 to 9, 4⅝c; Nos. 10 and 11, 4½ c; No. 12, 4⅝ c; No. 14, 5⅛ c. "Best Best," Nos. 6 to 9, 3¼c; Nos. 10 and 11, 3⅜ c; No. 12, 3½c; No. 14, 4c. Actual freight is allowed from basic points where it does not exceed 25c per 100 lbs.

Insulators. Glass insulators in lots of more than 1,000 and less than 10,000 are sold at the following prices per 1,000: Double petticoat, 20 oz., \$33; Western Union, \$30.25; No. 2, cable, \$53.90; No. 4, cable, \$210; Muncie type, 7 in., \$236.50; No. 3 triple petticoat, 4½ in., \$90.75.

Copper Wire (1913). Sales have been made at 18⅜ to 19 cents. Aluminum wire (1911), base about 31c.

TENTS AND CAMP EQUIPMENT

Tents are usually made of 8 oz., 10 oz. or 12 oz. single filling canvas, 10 oz. or 12 oz. double filling canvas, or of 10 oz., 12 oz. or 15 oz. Army duck.

A, OR WEDGE, TENTS WITHOUT POLES OR PINS.

Fig. 294. A or Wedge Tent.

Size (Ft.)	Height (Ft.)	8 -oz. Duck Single Filling	12-oz. Duck Double Filling
5x 7	6	$ 3.30	$ 5.00
7x 7	7	4.29	6.50
7x 9	7	5.61	7.75
9x 9	7	5.83	9.75
12x14	9	10.67	15.50

WALL TENTS WITH POLES, STAKES AND ROPES.

Size (Ft.)	Height Wall (Ft.)	Height Pole (Ft.)	8-oz. Duck Single Filling	12-oz. Duck Double Filling
7x 7	3	7	$ 5.50	$ 8.25
9x 9	3	7½	7.70	11.25
9x14	3	7½	11.52	15.70
12x14	3½	8	12.92	18.70
12x18	3½	8	15.12	22.00
14x16	4	9	17.05	25.00
14x24	4	9	22.00	32.50
20x24	5	11	30.00	42.00
24x50	5	13	65.00	95.00
30x70	6	15	110.10	150.00

Flies complete, half the price of tents.

Fig. 295. Wall Tent.

WALL TENTS, ROPED

Size (Ft.)	Height of Wall (Ft.)	Height of Pole (Ft.)	8-oz. Duck Single Filling	12-oz. Duck Double Filling	15-oz. Army Duck
21x30	5	11	$ 60.00	$ 85.00	$150.00
24x60	6	13	130.00	210.00	250.00
30x70	6	15	150.00	250.00	325.00

STABLE TENTS, INCLUDING POLES, PINS, GUYS AND GUY ROPES. SEMI-ROPED.

Fig. 296. Stable Tent.

Size (Ft.)	Height of Wall (Ft.)	Height of Center (Ft.)	8-oz. Duck	12-oz. Duck
24x36	6	14	$ 80.00	$105.00
24x72	6	14	130.00	175.00
28x63	6	16	135.00	180.00
28x81	6	16	160.00	210.00

EQUIPMENT

		Total wt.
Dining table		300 lbs.
3 doz. agate plates	$0.10 a piece	
3 doz. agate cups	.10 a piece	
3 doz. agate saucers	.10 a piece	
3 doz. steel knives	.75 per doz.	
3 doz. steel forks	.75 per doz.	
3 doz. plate spoons, tea	1.96 per doz.	
3 doz. plate spoons, dessert	1.96 per doz.	
3 doz. plate spoons, table	1.96 per doz.	
1 doz. salts	.10 a piece	
1 doz. peppers	.10 a piece	
¼ doz. 2-qt. pans	.48 a piece	
½ doz. 1-qt. pans	.35 a piece	
1 doz. 1-pt. pans	.29 a piece	
1 carving knife	.50 a piece	
7 yds. oilcloth	.20 per yd.	
3 trestle table		
5 boards, 12x1½x18 ft., dressed		
Cooking utensils, as required		300 lbs.
Miscellaneous, lamps, lanterns, stores, basins, tubs, pails		2,000 lbs.

The Cost of Framing and Flooring Tents is given by Mr. R. C. Hardman of Fort Huachuca, Ariz., in *Engineering News*, September 26, 1912, from which the following is abstracted:

The tents were of two sizes, viz.: 14 ft. x 14 ft. 2 in., and 6 ft. 11 in. x 8 ft. and were framed with 2x4 in. timber, braced with 1x6 in. timber and floored with 1x12 in. plank. The larger tent had 4 pairs of rafters and the smaller 3 pairs. The costs were as follows:

Large Tent:	
500 ft. B. M. lumber at $30.00	$15.00
7 lbs. nails at $0.05	.35
	$15.35
Small Tent:	
185 ft. B. M. lumber at $30.00	$5.55
5 lbs. nails at $0.05	.25
	$5.80

LABOR COST OF FLOORING AND FRAMING

Tents 14 ft. x 14 ft. 2 in.

38 Frames:	Cost	Cost per Tent
Carpenters, 32 hours at $0.50	$16.00	
Carpenter helpers, 129 hours at $0.375	48.38	
Laborers, 19 hours at $0.25	4.75	
Laborers, 11 hours at $0.20	2.20	
	$71.33	$1.877
42 Floors, Average Height 1 Ft. Above Ground, Leveled:		
Carpenters, 72 hours at $0.50	$36.00	
Carpenter helpers, 153 hours at $0.375	57.38	
Laborers, 81 hours at $0.25	20.25	
Laborers, 19 hours at $0.20	3.80	
	$117.43	2.796
		$4.673

Tents 6 ft. 11 in. x 8 ft. 4 in.

16 Frames:

Carpenters, 5 hours at $0.50	$ 2.50	
Carpenter helpers, 23 hours at $0.375	8.75	
	$11.25	.703
		$1.594

16 Floors, Average Height 1 Ft. Above Ground, Leveled:

	Cost	Cost per Tent
Carpenters, 9 hours at $0.50	$ 4.50	
Carpenter helpers, 26 hours at $0.375	9.75	
	$14.25	$0.891

Total Cost of Frame and Floor:

	Large Tent	Small Tent
Material	$15.35	$5.80
Labor	4.67	1.59
	$20.02	$7.39

TIES

The following shows the number of cross ties required per mile of track:

Distance From Center to Center (Ins.)	No. of Ties	Distance From Center to Center (Ins.)	No. of Ties
18	3,520	36	1,748
21	3,017	39	1,613
24	2,640	42	1,497
27	2,348	45	1,399
30	2,113	48	1,300
33	1,905	51	1,233

The cost in New York state of the average standard yellow pine railroad tie 6x8 ins. x 8 ft. was, in 1908, from 68 to 90 cents. Chestnut ties may average from 10 to 15 cents less, while cedar and cypress will be 20 to 30 cents cheaper. The ordinary contractor's tie suitable for narrow gauge track is generally purchaseable at about 40 cents. Ties 4x4 ins., in sections, are too small, as they split easily, and, therefore, ties smaller than 6x4 ins. should never be used. Ties used in narrow gauge tracks should be 2 ft. longer than the gauge.

Thirty-five standard gauge ties may usually be cut from a pine tree that is 14 ins. in diameter at a height of 5 feet above the ground. A skilled man can cut and trim 40 to 50 of these ties per day. The cost of cutting and hauling ties, provided the timber is growing in the immediate neighborhood, need not be more than 10 cents per tie.

The life of a tie depends largely upon its suitability for resisting the particular kind of attacks incidental to its surroundings. Oak ties in the fairly dry localities will hold spikes with great tenacity, and at the same time resist the effect of dampness very well, and may last 8 to 10 years. Under less favorable conditions, however, they may not last more than 7 years when untreated, while if thoroughly saturated with creosote or zinc sulphate, the average life may be 17 years.

The following table shows the life and cost of ties, etc.:

	—Wood—				—Concrete—	
	Untreated	Treated	Steel	C. I.	Reinforc.	Standard Beam
Life in years......	8	20	25	30	8	14
Cost delivered.....	.90	1.60	4.25	5.25	2.30	3.25
Cost of renewal....	.12	.12	.15	.15	.18	.18
Cost in track......	1.02	1.70	4.40	5.40	2.48	3.43
Value wornout ties.	...	...	.85	.75	.20	.53
Spacing c to c in ft.	1.875	1.875	2.	2.	2.	2.
Cost per lin. ft. track	.544	0.917	2.20	2.70	1.24	1.76
Value scrap per lin. ft. track.........	...	...	.42	.37	.10	.26
Annual cost ties per lin. ft. track.	0.81	0.067	0.131	0.149	0.173	0.152
Annual cost 1 mile track	427.68	353.76	691.68	786.72	913.44	802.56

The above costs are determined by substituting in the following formula:

$$x = c\,i + (c - v)\,s \qquad \text{If } v = 0 \qquad x = c\,(i + s)$$

where

x = Annual cost of ties per linear foot of track.
c = First cost in track per linear foot of track.
v = Value of wornout tie per linear foot of track.
L = Useful life of tie in years.
i = Interest rate per annum.
s = Annual payment into a sinking fund, which at the rate i for L years will amount to one dollar.

In the above table $i = 4\%$.

Track used on construction work is frequently moved. The ties will stand about three removals, and are then unfit for further use.

Mr. D. A. Wallace gives the following costs of unloading ties. Cost of train service:

Cost of work train, $25.00 per day; foreman, $50.00 per month; labor, $1.10 per day.

From coal cars while running: Train service, $1.04; labor, $0.45—total, $1.49; 250 ties at 0.6 cts. per tie.

Box cars while running: Train service, $6.24; labor, $5.35—total, $11.59; 970 ties at 1.2 cts. per tie.

Nine coal car work trains unloading in spots from 6:15 a. m. to 6:15 p. m. The cost of unloading per tie was: Delays, 0.48 cts.; unloading time, 0.29 cts.; running time, 0.83 cts.; total, 1.60 cts.

TOOL BOXES

Wooden tool boxes cost ready made or made on job:

6′ x 3′ x 2′ 8″	$11 00
5′ x 2′ 8″ x 2′ 6″	10.00

Wood tool carts with 42″ wheels:

Size of box, 82½ x 34½ x 25 ins. Price	$50.00
Size of box, 48 x 24 x 14 ins. Price	30.00

TRANSITS

A low priced and yet reliable transit, known as a builder's transit, weighs 6 lbs. and costs $85; with compass, 3-inch needle, $100. The tripod weighs 6 lbs.

A light mountain transit with a 7½-inch telescope, a 4-inch needle, complete, costs $200. Weight, instrument 5½ lbs., extension tripod, 7 lbs.

Mountain and mining transits with 9½-inch telescope and 4-inch needle, cost complete $235. Weight, instrument 10 lbs., tripod 9 lbs.

Surveyors' transits with a 5-inch needle weigh 16½ lbs. and cost $160.

Engineers' transits complete cost from $175 to $250 and weigh from 9 to 15 lbs.

TRACTION ENGINES

The prices of traction engines range from the prices given below to 30 per cent more.

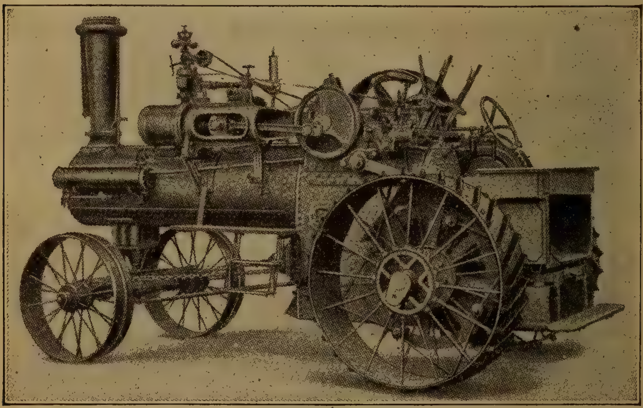

Fig. 297. 9x10-inch Cylinder Simple Traction Engine.

DESCRIPTIONS AND PRICES SIMPLE TRACTION ENGINE.

Length of Bore and Stroke (Inches)	Rated H. P.	Steam Pressure (Pounds)	Weight (Pounds)	Price	Miles per Hour at Normal Speed
7¼x10	9	130	10,917	$1,130	2.26
8¼x10	12	130	13,007	1,220	2.61
9 x10	15	130	14,206	1,365	2.62
10 x10	20	130	15,823	1,600	2.61
11 x11	25	130	20,368	1,880	2.52
12 x12	32	160	32,600	2,820	2.37

COMPOUND TRACTION ENGINE.

Length of Bore and Stroke (Inches)	Rated H. P.	Steam Pressure (Pounds)	Weight (Pounds)	Price	Miles per Hour at Normal Speed
5¾x 8½x10	9	130	.....	$1,220	2.26
6⅛x 9 x10	12	130	.....	1,315	2.61
7 x10 x10	15	130	.....	1,455	2.62
7¾x11 x10	20	130	.....	1,690	2.61
9¼x13 x11	25	130	.....	1,975	2.52

For Straw Burning Attachment, including Jacket on Boiler, add $47 to prices above.

All Straw-Burning Engines are jacketed unless otherwise ordered. For Jacketing Coal-Burning Engine (except 32 H. P.) add $128.

Locomotive Cab for 32 H. P. engine, $70.

If wider tires than those regularly furnished on engines are wanted, for each 2 inches extra width, add to list price $23.50. No reduction if narrower tires are ordered.

Repairs on traction engines are about 10 per cent more than on rollers.

Fig. 298. 45 H. P. Tractor Pulling a 25-Ton Load up a 5 per cent. Grade in the City of Delaware, Ohio.

Gasoline Traction Engines, Fig. 298, with friction drive and a patent steering device are as follows:

H. P.	Fuel, Tank Capacity (Gallons)	Water, Tank Capacity (Gallons)	Weight (Pounds)	Price
20	80	60	11,000	$1,975
30	100	70	14,000	2,450
45	200	80	19,000	2,750
70	200	90	25,000	3,300

Regular road speed, 1½ to 2½ miles; third speed, 3½ miles. Gasoline traction engines with equipment for converting them into rollers cost $400 extra.

MOTOR TRACTION ENGINES

In the effort to reduce the cost of wagon haul below that of ordinary team transportation, trials have been made of traction engines of various designs. It was found that the familiar types of engines with comparatively narrow wheel treads, were useless in the deep dust and sand of desert roads. A special type, however, called the "Caterpillar" or "Paddlewheel" Engine, Fig. 299, so designated from the peculiar construction of its rear

and propelling wheels, has been placed in service with good results.

This engine, instead of the large hind wheel commonly known, carries its weight on five truck wheels which run on a track of plow steel, so protected that it is nearly impossible for sand to reach the bearings. The hind wheels are of the sprocket type

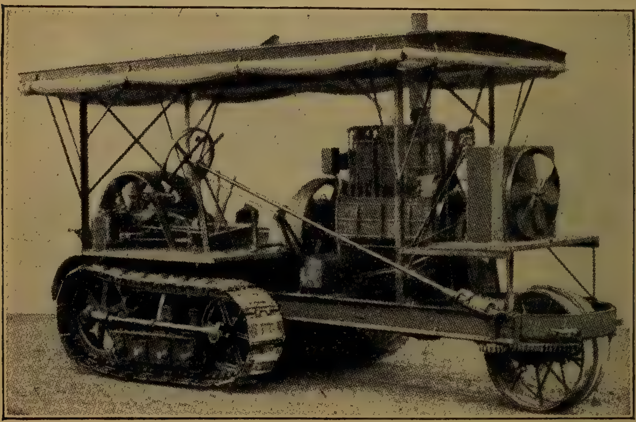

Fig. 299. Caterpillar Tractor.

and engage an endless belt of "shoes" or "platforms" which pass around the sprocket and center wheels, 78 inches distant, the latter acting as idlers. These platform wheels have the same tractive area as an ordinary round wheel, 54 feet in diameter.

The motor used is of the four cylinder, vertical, water cooled type, with 6-in. x 8-in. cylinders, developing 40 brake h. p. at 550 R. P. M. Distillate is used for fuel at a cost of less than 1 cent per h. p. per hour.

The capacity of these engines naturally varies with the grade. Loads of from 15 to 20 tons are possible on level roads. Specially built trucks capable of carrying from 6 to 10 tons are used. Compressors, transformers and other heavy machinery, weighing from 7 to 10 tons, are easily transported over loose sand on grades ranging from 12 to 20 per cent, and around the sharp curves of mountain roads. Ordinary wagon transportation of such loads under like conditions would be an impossibility.

Accurate cost data have been kept of the performance of these machines, together with team haul, for the purpose of comparison. Recent work in the Jawbone and Mojave sections shows an average ton mile cost of 20 cents for engine haul, against an average of from 40 cents to 50 cents for team transportation.

The report of July 1, 1909, shows that the average ton mile

cost 25 cents for the period ending at that time, whereas the lowest bid received for this work was 80 cents per ton mile.

The cost of operating fifteen of these engines during February, 1910, was as follows:

	Total	Average per Engine	Per Ton Mile
Supplies	$ 955.18	$ 63.68	$0.0367
Repairs	2,161.47	144.10	0.0825
Labor, crew	2,003.27	133.55	0.0771
Depreciation	725.00	48.33	0.0279
	$5,844.92	$389.66	$0.2242

The price of the above engine, single speed, 2¼ miles per hour:

6½x8 cylinders, spring mounted, weight fully equipped 18,000 lbs.	$3,250.00
Extra for 2 speed, 5 miles per hour	250.00
Extra for stationary attachment	250.00

Tank capacity, distillate, 70 gallons.
Tank capacity, water, 56 gallons.
Length over all, 18 ft. 4 in.; width, 7 ft.
Distillate consumption, 3.5 gallons per hour.
Motor, 30 H. P. rated; 45 H. P. brake capacity.

THE GASOLINE TRACTION ENGINE COMPARED TO THE HORSE

Mr. L. W. Ellis read a paper at the annual meeting of the Gas and Gasoline Engine Association at Cincinnati, Ohio, June 16, 1910, from which I have made the following abstract:

Properly handled, working about six hours a day, well and carefully fed, a horse may have a working life of ten years of 1,000 hours each. Where used on street car systems, his life of usefulness is from two to four years. The average farm horse will do well to develop 500 H. P. hours per year or 5,000 in ten years. A tractor, carefully looked after, would probably double this for each rated H. P.

About 20 per cent of the horse's weight may be taken as his maximum sustained draft, and six to eight miles per hour his maximum sustained speed for anything more than an hour or so per day. The draft horse ordinarily gives the largest volume of work per day at about one-half his maximum load, and one-third his maximum speed.

One reason for the great flexibility of the horse is the fact that he works most economically at about 1 lb. of draft for 10 lbs. of weight, or from 50 to 20 per cent of the rate he can exert in a pinch. In the motor contests at Winnipeg last year the gas tractors exerted 1 lb. of draft for 4¼ lbs. of weight on a good sod footing, and for 6 lbs. of weight on a soft dirt and gravel course. The average horse develops one useful horsepower for 1,500 lbs. of weight. Nine of these tractors, which completed all the tests, developed 1 brake H. P. for 465 lbs. of weight, and under both good and bad footing 1 tractive H. P. for 922 lbs. of weight.

The horse needs a drink and food after every seven to eight miles of plowing, but of course can be forced to go a greater distance. Some of the best known gas tractors could go from 10 to 15 miles under full load if it were possible entirely to empty the fuel and water tanks without stopping. Actually they need water about as often as the horse. Others of different type could go for 15 to 20 miles without fuel and several times that without water, with their present tank capacity. A better balance in this respect would render the tractors more convenient, and undoubtedly some weight would be eliminated in so doing. A steam plowing engine does well to travel two miles on the water taken in during 15 mins. Probably 95 per cent of the weight may be put into metal, 2½ per cent into the cooling water and 2½ per cent into fuel. The latter may be increased easily in tractors designed for use in dry stretches.

The gas tractor cannot compete with the horse as a hauling proposition on heavy grades. The elimination of steep grades, which a horse may surmount by the expenditure of greatly increased energy, but which exhaust the overload capacity of tractors, will mean not only an increased use of mechanical motors for hauling purposes, but an excellent field for traction machinery in the building and maintenance of good roads.

One man in the field may handle four to six horses, developing from 2½ to 4½ H. P. Two men on a gas tractor will handle an outfit doing from 10 to 20 times the work. To care for a traction engine doing the work of 25 horses requires approximately the same time in the course of a year as to care for one horse.

TRENCHING MACHINES

The term Trench Machine comprises machines of many varied types, such as cableways on which are operated buckets, steam shovels with booms and buckets especially designed, and elevator bucket machines.

Machines for trenches over 10 feet deep and 3 to 10 feet wide consist of a rail supported on A frames, carry six tubs (each holding ⅕ cubic yard) at a time, spaced 8 feet apart. Length over all, 336 feet, and length of working section, 288 feet. One-third of the length is given over to trench digging, ⅓ to brick or concrete masonry construction and the remaining ⅓ is being back-filled. Width of machine, 8 feet, and height, 14 feet. It stands on a track of tee rail and can be pulled ahead to a new position by its own engine in a few minutes. Price, complete with engine, and including an expert's services to assist in erecting, $3,366 f. o. b. cars. Rental, $200 per month for terms of four months or more, lessee paying freight one way, and $4 per day and expenses of expert during erection. Capacity as stated by the manufacturer is 250 cubic yards per ten hours.

A machine for pipe sewer work is similar to the one above described except that it has a working length of 240 feet and weighs about 23 tons; price, $3,211. Rental the same as for the larger machines.

Each of the above machines can be loaded on one flat car 34 feet long. The average time of setting up and starting a new machine on a new job is from five to seven days. A contractor states that it took him two days to dismantle a machine, move 1,000 feet, and set up again.

Mr. A. W. Byrne used a machine of this type in a 4,000 ft. section of the Metropolitan sewer system, at Boston. The force was as follows:

1 engineman	$ 3.00
1 lockman	2.00
1 dumper	1.50
8 shovelers, at $1.75	14.00
2 bracers, at $2.50	5.00
2 tenders, at $2.00	4.00
4 plank drivers, at $2.00	8.00
2 men cutting down planks, at $2.00	4.00
8 men pulling planks, etc., at $1.75	14.00
Total	$55.50

The trench was 9 ft. wide x 20 to 30 ft. deep, and this force averaged 64 lineal ft. per week in running sand, 192 ft. in gravel and coarse sand at a cost ranging from 80 to 25 cents per cubic yard. A steam pump costing $10 per day was required, and about ½ ton of coal was required for the trench machine.

A Cableway can be used to advantage on trenches 8 feet and wider. The main cable is stretched on towers 30 feet high and three to four hundred feet apart. One tub of one cubic yard

capacity is handled at a time and can be loaded at any point and swung as much as 10 feet to one side. The cable machine is advantageous in soft digging or on rock as no part of the machine is carried by the side banks. The engine and one tower stand on a car which runs on tee rails; the other tower stands on the ground and must be lowered and carried to a new position. The outfit can be loaded on one car and weighs about 19 tons; price of 300 foot cableway is $3,250; rental, $200 per month; capacity, according to the manufacturer, 350 cubic yards per ten hours; price of 400 foot cableway, $3,500; rental, $225 per month.

West of a north and south line from Buffalo, N. Y., add $50 to the selling price of the cableways.

On rented machines repair parts are furnished by the lessor, the lessee paying carrying charges and cost of replacing. General repairs are such as are necessary on any contractor's hoisting engine in constant use, together with the replacing of worn out steel ropes and running parts, which are comparatively small items, as there are no parts subject to frequent breakages as in the case of steam shovels and ditch digging machines.

These cableways are usually driven by a 7"x10" double cylinder engine capable of lifting 5,000 lbs. They raise and transport the buckets at a speed of about 440' per minute. The output is about 250 cubic yards of rock per day. Mr. James Pilkington, of New York, says that he has taken the machine down, moved 250' and put it up again in three hours and fifty minutes.

The following costs are from "Earthwork and Its Cost," by H. P. Gillette, for a sewer in Washington, D. C.:

Width of trench, 18 ft.; depth at which cableway began work, 15 ft.; distance of travel of 1 cu. yd. bucket, 150 ft.; number of trips per hour, 35; hours per day, 8; material, cemented gravel. Cost:

Engineman	$ 2.00
Fireman	1.25
Signalman	1.00
2 dumpers, at $1.00	2.00
Coal, oil and waste	1.50
Interest and maintenance (estimated)	7.00
	$14.75
30 men picking and shoveling	30.00
Total for 280 cu. yds	$44.75

Cost of picking, shoveling, hoisting 15 ft. and conveying 150 ft. to wagons, 16 c. per cu. yd. (Note that the wages were very low.) Bracing and sheeting were going on at the same time; the men did not know they were being timed.

A self-propelling machine for excavating small trenches and which digs by means of scrapers and buckets fastened at the rim of a revolving wheel is said by the manufacturer to be able to excavate in any ground that can be loosened with a pick. The machine will cut through a log or timber, but if it strikes a large boulder the wheel must be raised out of the trench until the obstruction is passed. These machines cost about $250 per ton.

METHODS EMPLOYED IN CONSTRUCTING CONCRETE PIPE SEWER IN JACKSON, MICH.*

Special methods and devices for trenching and pipe laying have been employed in constructing two lock joint concrete pipe trench sewers in Jackson, Mich. These sewers vary in diameter from 4 ft. to 18 ins., and each is about 2 miles long, and the lock joint concrete pipe is used for 24 ins. in diameter and above, vitrified pipe being used for the 18-in. line.

The trench is largely through sand and gravel and considerable water and running sand were encountered. The depth ran from 7 ft. to 25 ft. and tight sheeting was required throughout. The first few feet of cut were made with horse and scraper; if the trench did not exceed 8 ft. in depth the deepening was continued by hand; for depths exceeding 8 ft. a trench machine was used. The sheeting was driven by hand and was pulled after the trench had been nearly refilled by means of a chain block fastened overhead to a rail laid on the bents of the trench machine. Two men pulled all the sheeting.

The trench machine is shown by Fig. 299A. It was designed by City Engineer A. W. D. Hall, and, built 150 ft. long, cost $500, including three ½ cu. yd. self-dumping buckets. The construction calls for very little explanation. As will be seen, the whole machine is made so as to move along the work on track rails laid on the banks of the trench. An ordinary double drum hoisting engine operates the traveler, one drum giving the traveling movement and the other drum doing the hoisting. The usual method of operation was employed. The excavated spoil was raised in the buckets, conveyed back and back-filled onto the pipe, which had been laid as fast as the trench was opened.

When water was encountered in the trench it was handled as shown by the sketch, Fig. 299B. The force pipe of an ejector, shown in enlarged detail by Fig. 299B, was attached by hose to the nearest hydrant, which gave the ordinary domestic pressure of about 60 lbs.; the suction pipe with strainer end drew from the trench sump and the discharge pipe passed over a bulkhead into the completed sewer.

In pipe laying the usual methods were followed, the pipes being rolled onto skids over the trench and lowered by the trench machine. The pipe laying was straightforward work except where running sand or quicksand was encountered and then the special shield shown by Fig. 299C was employed. This shield consists, as will be seen, of three sides of a bottomless box. It is operated as follows: When near grade the shield is set on the trench bottom in the position illustrated, with its open end straddling the end of the completed pipe. Hay is then stuffed into the spaces between the sides of the pipe and the sides of the shield to keep the mud out and two men inside the shield excavate down to grade, driving down the shield as they sink the excavation. When the excavation is completed the pipe is laid

* *Engineering-Contracting,* Nov. 10, 1909.

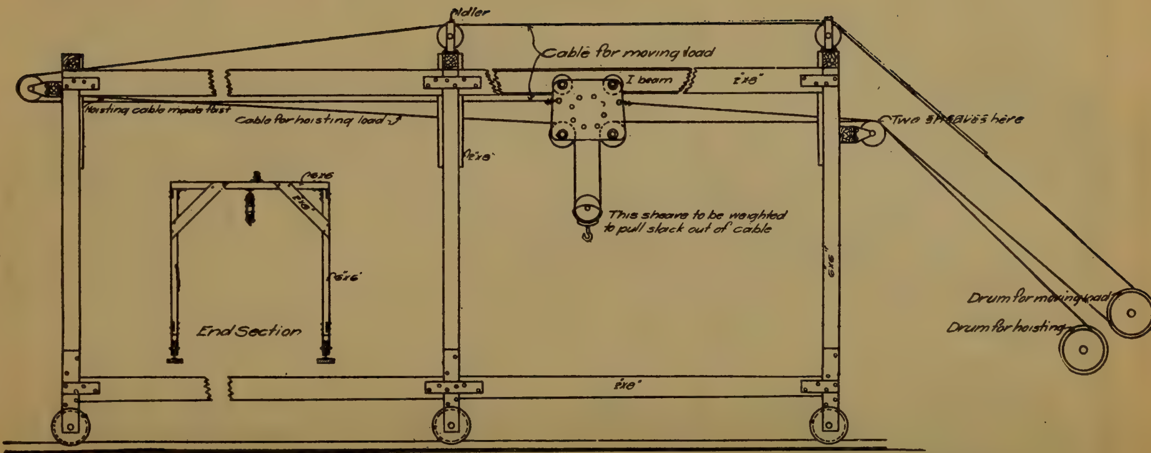

Fig. 299A. General Details of Trench Machine Used on Sewer Work, Jackson, Mich.

and jointed inside the shield, which meanwhile acts as a temporary cofferdam.

Only general figures are available on the cost of this work. Mr. Hall states that for depths of 10 ft. and less the cost has

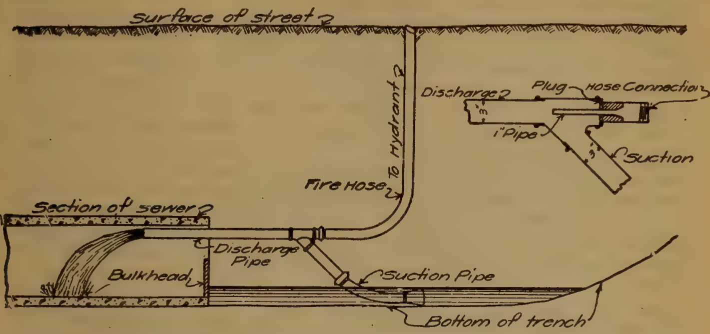

Fig. 299B. Sketch Showing Ejector and Method of Pumping Water from Sewer Trench.

varied so much owing to local conditions, differences in material, etc., that it is impossible to get at average costs. He states that the cost of excavating 42-in. sewer from 17 to 20 ft. deep has been 53 cts. per cu. yd. The trench at 17½ ft. depth con-

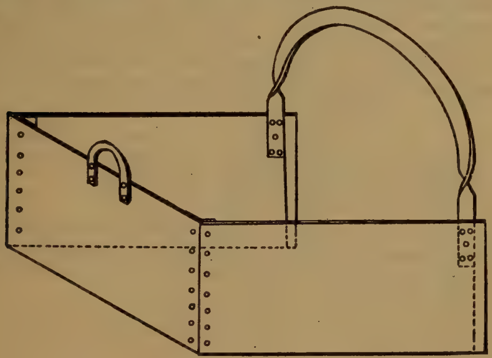

Fig. 299C. Sketch Showing Steel Plate Shield Employed in Laying Sewer Pipe.

tains 4.7 cu. yds. of excavation per lineal foot and costs $2.50 per lin. ft. At a depth of 26 ft. the trench contains 7.05 cu. yds. of excavation and costs 75 cts. per cu. yd., or $5.28 per lin. ft. of trench. Between 17 ft. and 26 ft. depth the costs vary about

in proportion from 53 cts. to 75 cts. per cu. yd. These costs include excavation, back filling, driving and pulling sheeting, pipe laying and cleaning up and grading the street after the work. They include everything except cost of pipe and cost of sheeting timber and, apparently, plant and overhead charges. The gang worked consists of 30 men; common labor is paid $2 to $2.25 per day, enginemen $3 per day and foremen $5 per day. The work is being done wholly by day labor. The information from which this article has been prepared has been furnished us by Mr. A. W. D. Hall, city engineer, Jackson, Mich.

Mr. H. P. Gillette, in *Engineering and Contracting*, gives the results of his observations of a No. 17 machine of this type. The original cost was $4,800, but the market price of this machine new is now $5,250. Mr. Gillette estimates the interest and depreciation over 150 working days at $7.00 per day, which was equivalent to 1½ cents per yard. He gives the cost per lineal foot of trench as 4 cents and the cost per cubic yard as 10 7/10 cents.

Another type of self-propelling trench excavator can attain a road speed of 2½ miles per hour. The earth is excavated by buckets traveling on a chain elevator and is removed to the side of the trench on a belt conveyor. The buckets are self-cleaning and travel across the face of the trench in order to excavate to the proper width which is regulated by two set screws. It is not necessary to change the buckets or scrapers to change the width of the trench. The manufacturers rate their machines at ¾ cu. yd, per minute. The machine is operated by one man; coal consumption 1,200 to 2,000 lbs. per 10 hours. The weight of the machine is well ahead of the trench. It is not suited for very rocky ground, but when a large boulder or similar obstacle is met the buckets can be raised over the obstruction and can start again on the farther side of the obstruction.

	Width of Trench	Depth	Weight (Tons)	Price
Small machine.......	28″ to 60″	0′ to 20′	18	$6,700
Large machine.......	28″ to 78″	0′ to 30′	20	7,600
F. o. b. factory.				

Another excavator of the self-propelling type and in which the earth is excavated by scrapers and buckets traveling on a chain elevator and removed to either side of the trench on a belt conveyor is shown in the following table.

TABLE 152—SIZES AND CAPACITIES OF TRENCH MACHINES.

Size No.	Kind of Power	Horsepower	Maximum Depth	*Approximate Widths	Max. Speed of Digging per Min.	Miles Traction per Hour	Delivers Dirt on One Side or Either Side	Width on Car	Height Over All	Price
000	Gasoline	15	6′	12 and 15	8′					$ 3,500
00	Gasoline	20	8′	12, 15 and 18		1½	One Side	9′	11′	4,500
00	Steam	12	6′	12, 15 and 18	8′	1½	One Side	9′	11′	4,500
0	Gasoline	36	10′	19 and 26	10′	1½	Either Side	10′	12′	6,500
1	Steam	20	12′	19, 24 and 27						
		9x11 †		32 and 36	6′	1¼	Either Side	10′	14′	7,500
1½	Steam	40		19, 24 and 27	4′	1½	Either Side	10′	14′	8,000
		10x10 †	14′	32 and 36						
1¾	Steam	40	15′	27, 32 and 36	2½′	1½	Either Side	10′	15′	10,000
3	Steam	10x10 †								
		70	25′	27, 32 and 36	3′	1½	Either Side	10′	15′	15,000
		12x12 †		48 and 60						16,000

* These widths can be varied by change of side cutters.
† Dimensions of engine.

The manufacturers say that the machine will probably need no repairs for one year; then the repairs on No. 000 to No. 0 will cost from $1 to $2 per day; on the larger machines $2 to $5 per day. These machines are self-propelling both for digging and traveling, no cables being used. Usually the tractions on these machines are of the wheel type, large in diameter and having a wide face. For traveling over streets this is satisfactory, but for operating in soft ground the rolling platform traction is recommended. These machines have various changes of speeds

Fig. 300. View of Trenching Machine Excavating Sandy Clay at West Salem, Wis.

and can be changed instantaneously by the operator. In order to change the width of the trench the scrapers must be removed and others of the proper dimensions substituted for them. These machines are for lease also on a fixed sum per hour or per day plus a fixed sum per yard basis. This rental includes the engineer's services and will average about $50 per day.

PROGRESS DIAGRAM AND DISTRIBUTION OF TIME OF FORCE ON SEWER TRENCHING BY MACHINE.

After W. G. Kirchoffer.

Recently an 8-in. sewer 5,270 ft. in length was laid at West Salem, Wis. The excavation was made in a sandy gravelly clay by the use of a Parsons' trenching machine. Fig. 300 shows the machine in operation. The trench averaged about 8 ft. deep. The total number of days' work put in on the job was 325¾, or an average of 61.8 days per 1,000 ft. of sewer. The trenching machine was operated 20 days out of the total 26 put in upon the work, or an average of 263½ ft. per day. The least distance made in a day was 20 ft. and the maximum distance was 550 ft.

of completed sewer. There were five days in which the rate exceeded 400 ft. of sewer per day. The progress diagram is shown in Fig. 301.

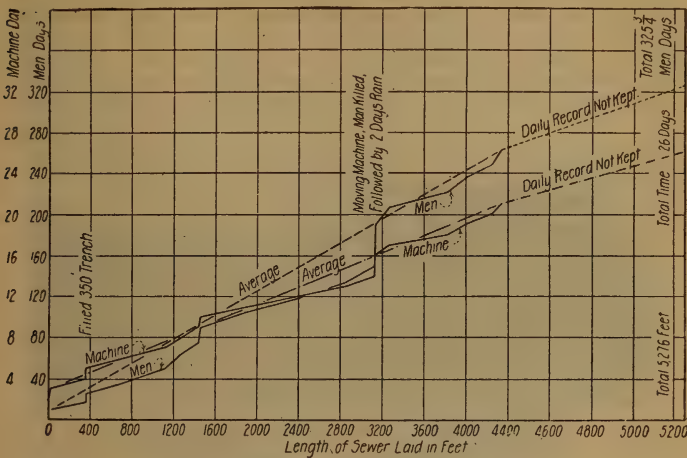

Fig. 301. Progress Diagram of Sewer Trenching Machine at West Salem, Wis.

The labor upon the work was divided as follows in days per 1,000 ft. of sewer:

Contractor	1.092
Inspector	4.935
Pipe layer	4.315
Foreman	4.270
Engineer	4.79
Fireman	4.412
Team	3.417
Mason	3.75
Water boy	1.993
Common labor	26.04
Tamper	4.13

The greatest number of men employed in any one day was 16 and the smallest number was two.

This work was done under the supervision of W. G. Kirchoffer, consulting engineer, Madison, Wis. The contractor was F. E. Kaminski of Watertown, Wis.

TRENCHING BY MACHINE FOR A 36-IN. BRICK SEWER.*

An interesting example of machine trenching under favorable conditions of soil is furnished by the sewerage of an area of about 30 square blocks south of 80th St. and east of Aberdeen

* *Engineering and Contracting*, July 17. 1912.

St., in Chicago, Ill. The sewers to be built comprise about 665 ft. of 36-in. brick sewer, about 2,200 ft. of 30-in. brick sewer and some 17,000 ft. of 15 and 18-in. pipe sewer. The depth of these sewers below natural ground surface is an average of 14 ft. The soil consists of black loam overlying yellow and blue clay, the clay being stiff enough to stand well with only occasional sheeting planks. Altogether the soil conditions are well fitted for trenching by machine and all trenching is planned to be done by machine. Fig. 302 shows the machine used which is a No. 1

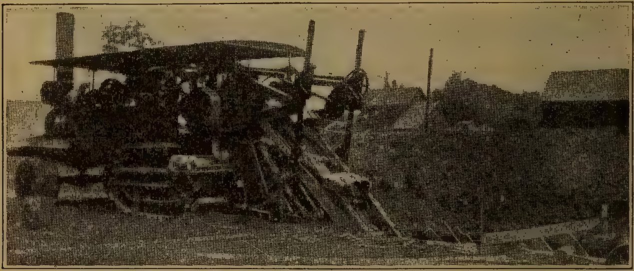

Fig. 302. View of Austin No. 1 Trench Machine Digging a 15-ft. Trench 42 Inches Wide.

Austin Trench Excavator fitted with buckets cutting to a width of 42 inches.

The work at present is on the 36-in. circular sewer, which consists of a two-ring invert and a single ring arch. Following the machine the trench bottom is troughed to templets of the sewer inverts. For this larger sewer the trench sides were to be undercut at the bottom, since the excavator cuts only 42 ins. wide, but with the smaller sewers there will not be this extra work. Three men pick the bottom and undercut the sides behind the excavator, which is kept about 15 ft. ahead of the invert masons. Vertical plank spaced about 2 ft. apart and bound with pipe and iron bands are sufficient to keep the trench sides safe.

Three bricklayers work on the inverts and two work on the crown which follows from 30 to 50 ft. behind. Brick handlers, mortar men and helpers bring the force on brick work up to 30 men. The invert brick are laid to the templet cut trench bottom. To undercut the arch flat iron circles in two parts connected by bolts are set 6 ft. apart on the completed inverts and 2x4 in. lagging is laid on them to form the arch center. The rings are collapsed by removing the connecting bolts.

Trench excavation was begun June 3 and at the time the work was visited, July 8, 1,600 ft. had been excavated. This, however, is no indication of the speed of the excavator, for it is worked only fast enough to keep some 15 ft. ahead of the invert masonry. On two favorable days, 184 ft. and 170 ft. of sewer were built,

but the average advance has been much less. The contractor stated that the machine had not worked over half the time.

An estimate of the cost of operating the excavator based partly on assumed progress, is as follows:

Engineer	$5.00
Fireman	2.50
Coal	4.00
Oil and waste	.50
Repairs	1.00
Depreciation	2.73
Interest at 5 per cent	1.37
Total cost per working day	$17.10

The machine will use about three-quarters ton of coal per day. To be conservative we have assumed one ton at $4.00. The

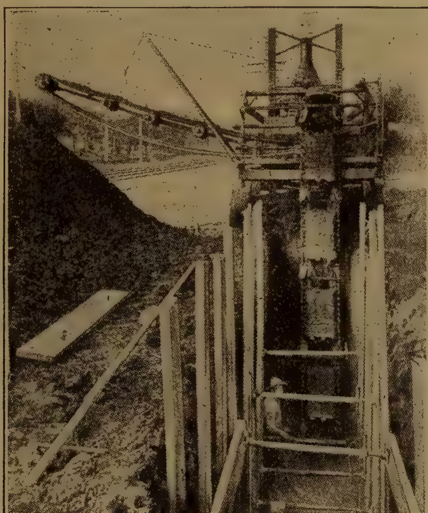

Fig. 303. Excavating Trench for Sewers Seventy-Eight Inches Wide and Twenty Feet Deep at Des Moines, Iowa.

repairs were also estimated at $1.00, which is considered liberal. The depreciation is taken at 300 days' work per year for ten years, and although it is assumed that the owner of such a machine will be able to sell it at the end of that time, no allowance for salvage value is made here.

Assuming that the brick sewer may follow the machine at a rate of 170 ft. per day, the cost per foot of trench excavation is 10 cents, or 5 cents per cu. yd. If the contractor could double the rate of brick construction he could then reduce the

excavation cost by one-half, as he states that the machine is used about 50 per cent of the time. Other items enter into the increase in speed of brick sewer construction which might increase the cost of that part of the work more than the reduc-

Fig. 304. Carson Trench Machine Purchased by City of Brandon, Manitoba, Canada, and in Use on First Street Sewer. Hoists Six Tubs at a Time.

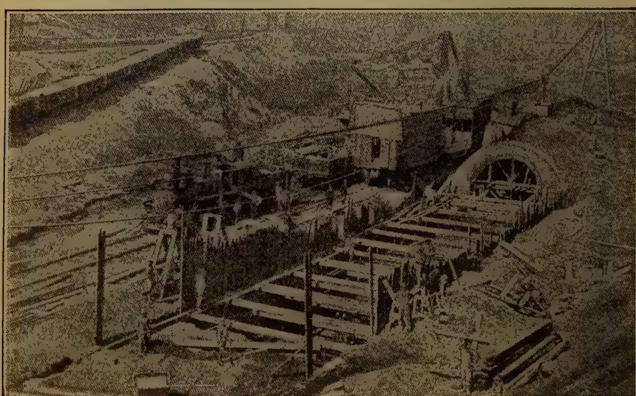

Fig. 305. Carson-Lidgerwood Cableway on Work of Bramley & Gribben, Walworth Run Sewer, Cleveland, O.

tion in cost of excavation. The decrease in cost of excavation on the 3,000 ft. of brick sewer if built at twice the rate of speed would be $3,000 \times 5$ cents, or \$150, which is hardly enough to warrant the risk of increasing the cost of the brick work.

Figs. 303-305 illustrate well known trenching machines on various types of construction.

TRUCKS

A three-spring, short turn, light truck with side and tail boards, weighing 810 lbs. and holding 1 ton, costs $85.00.

A two-horse truck, weighing 2,000 lbs. and holding 2¼ tons, costs $255.00.

A two-horse truck, weighing 2,300 lbs. and holding 2½ tons, costs $270.00.

A two-horse truck, weighing 3,500 lbs. and holding 4 tons costs $350.00.

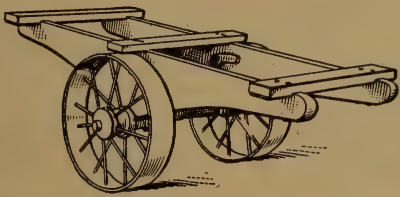

Fig. 306. Timber Buggies or Trucks.

Timber Buggies or Trucks—Used extensively by builders for handling heavy beams and timber. Size, 4 ft. long, 2 ft. 8 in. wide. Made from hard wood. Wheels, 24 ins. diameter, 4 ins. face. Axles, 2 ins. square. Price, $25.00.

TUGS

*In connection with the dredging work and other construction tributary to the park extension work at Lincoln Park, Chicago, a fleet of tugs and other floating apparatus was employed.

The tug "Keystone" has a steel hull 87½ ft. long, 19 ft. beam, and 11 ft. deep. She is of 94 gross ton weight, and was built in 1891. She contains 1 fore and aft compound condensing engine with 18x34 in. cylinders of 30 in. stroke, and one fire-box marine boiler, 14 ft. long x 102 in. in diameter, carrying steam at 125 lbs. The crew is as follows:

	Per Month
1 Captain	$165.00
1 Engineer	120.00
2 Firemen	65.00
1 Deckhand	65.00
1 Scowman	65.00
1 Watchman	66.00
1 Cook including supplies	222.50

This tug was in commission 12 hours per day. Board was furnished the men in addition to the regular wages. The tug was purchased by the Park Commission in 1905 at a cost of $13,983.19, including improvements, and was fitted with Jones underfeed stokers in 1910 at a cost of $2,025, making its total cost $16,008.19. It has been in commission 2,348 hours. The cost of operation in 1910 was as follows:

	Cost	Cost per Hour
Labor operation	$5,485.63	$2.336
840 tons coal	2,772.50	1.180
Supplies	915.56	.390
Insurance	127.50	.055
Labor repairs	1,057.76	.450
Material repairs	903.06	.385
Total cost of operation	$9,301.19	$3.961

Summarizing we get the following costs:

Total cost of repairs	$1,960.82
Cost of operation per hour	3.961
Cost of operation per day	47.55
Cost of repairs per hour	0.835
Cost of repairs per day	10.05

The tug was mostly used for towing scows loaded with loam for park purposes, but 89 hours of its time were charged to dredging.

This tug again served the dredge from April 20 to June 9, 1911, on which date she picked up one of the dredge cables in her wheel. She was docked on June 14, and a new rudder of wood

* From *Engineering and Contracting*, Vol. XXXV, No. 8, Vol. XXXVII, No. 24.

placed on her. The tug went into commission again on June 19 towing black soil from that date till Jan. 1, 1912. During the season she towed 39,000 cu. yds. of black soil at a cost of 17½ cts. per cu. yd., and 12,000 cu. yds. of stone, 8,060 cu. yds. of which were handled before Dec. 1, in conjunction with the black soil at a cost of 33 cts. per cubic yd., and 3,940 cu. yds. after Dec. 1 at a cost of 55 cts. per cu. yd. The table gives by items the cost of operation and repairs for the season.

Hours in commission 2,377¼

	Total	Per hour
Operation.		
Labor	$ 6,699.70	$2.86
Watching	89.34	
Fuel	4,230.00	1.78
Supplies	1,123.51	.47
Insurance	127.50	.05
Miscellaneous	234.81	.10
Total	$12,504.86	$5.26
Repairs.		
Labor	$ 1,891.28	$0.80
Material	1,316.12	.55
Teams	3.40	
Derrick	44.96	.09
Hausler	55.35	
Richard B	98.39	
Total repairs	$ 3,409.50	$1.44
Total operation and repairs	$15,914.36	$6.70

The tug "Richard B." is 76 ft. long, 17 ft. beam, and 7 ft. in depth. She has a wooden hull and is rated at 63 gross tons. Equipment comprises one fore and aft compound condensing engine, 10x20 in. cylinder, with 14 in. stroke. Her boiler is Scotch marine type, 14 ft. long by 96 ins. diameter, and carries 125 lbs. of steam. She was built in 1906. Her crew consists of a captain at $145, an engineer at $120, a fireman and a lineman each at $65. The tug was purchased by the Park Commission in 1905 for $8,744.55, which price included some repairs and improvements made before placing in commission. The cost of operation and repairs during 1910 were as follows:

Hours in commission	1,118
Hours leased	732
Hours on park extension	386

Item	Cost
Labor operation, 386 hours	$ 476.88
Fuel, 386 hours	315.75
Supplies	104.03
Insurance	95.00
Labor repairs (winter)	511.35
Material repairs	534.41
Towing repairs	21.76
Total operation, 386 hours	991.66
Total repairs, 1,118 hours	1.067.52
Total operation and repairs	2,059.18
Total cost per hour	3.53
Total cost per day	42.36

The time of this tug was charged to the dredge work for 139 hours. It was in commission 12 hours a day.

This tug was in commission again after March 7, 1911, and was engaged in miscellaneous work on days when needed and went into continuous service on July 11, serving the breakwater construction fleet, assisting the "Hausler" in serving the dredge and towing black soil from the river to the work. Her cost for the season is given by the following table:

TABLE 153—COST OF OPERATION AND REPAIRS OF TUG "RICHARD B."

Hours in commission 2,184½

	Total	Per Hour
Operation.		
Labor	$4,054.90	$2.06
Watching	446.68	
Fuel	1,235.75	.57
Supplies	351.08	.16
Insurance	109.54	.05
Miscellaneous	3.33	....
Total operation	$6,201.28	$2.84
Repairs.		
Labor	$ 366.40	$0.17
Material	172.84	.08
Pile driver	197.67	.10
Derrick	26.27	
Total repairs	$ 763.18	$0.35
Total operation and repairs	$6,964.46	$3.19

The cost of operation of the motor boat is given below for eight months. Its time was charged to the entire fleet.

	Total	Per Day
Operation.		
Labor	$ 520.00	$3.56
Supplies	335.73	
Total	$ 855.73	
Repairs.		
Labor	$ 291.81	
Material	13.72	
Derrick	85.45	$1.63
Total	$1,246.71	$5.19

The tug "Hausler," the last of the three tugs belonging to the fleet, is 72 ft. long, 18 ft. beam, 9 ft. deep, and is rated at 61 gross tons. She was built in 1893 of wood. Her machinery consists of 1 vertical non-condensing engine, 22x44 in. cylinder with 24-in. stroke. She has 1 fire box marine boiler, 14 ft. long x 96 in. in diameter, carrying 135 lbs. of steam. Her crew consisted of a captain at $165, engineer at $120, and two firemen and

one deckhand at $65. As she was in commission 24 hours per day it was necessary to provide a double crew, each working a 12 hour shift. This tug was purchased in 1908 for $10,500. The cost of operation and repairs for the season of 1910 was as follows, for 5,537.5 hours in commission:

	Total	Cost per Hour	Cost per Day
Labor operation	$ 8,283.92	$1.496	$17.95
Fuel, 773 tons	2,903.00	.524	6.29
Supplies	369.65	.667	.80
Insurance	250.00	.045	.54
Labor repairs	1,317.26	.238	2.86
Material repairs	1,897.63	.343	4.12
Towing repairs	14.12	.....	.02
Total operation	11,806.57	2.130	25.58
Total repairs	3,224.01	.590	7.06
Total cost	15,035.58	2.720	32.64

This tug devoted nearly all its time to the dredge during 1910.

In 1911 the tug "Hausler" did not go into commission until June 15 on account of repairs to her boiler which required from Feb. 20 to June 2. The furnaces were practically rebuilt. The cost of her operation for the season is shown as follows:

Hours in commission....................................3,602½

Operation.

	Total	Per Hour
Labor	$ 7,120.70	$2.03
Watching	178.67	
Fuel	2,583.93	.72
Supplies	644.03	.18
Insurance	268.75	.07
Total operation	$10,796.08	$3.00

Repairs.

Labor	$ 791.13	$0.22
Material	2,864.93	.80
Derrick	185.50	.08
Richard B.	119.03	
Total repairs	$ 3,960.59	$1.10
Total operation and repairs	$14,756.67	$4.10

TOW BOATS

Under "Barges" are described a number of such boats used on the upper Mississippi and whose cost, life and cost of repairs are described. I herewith append a list of tow boats used on this improvement.

Tow Boats. There are three sizes of tow boats used which are designated as large, medium and small. Of the boats mentioned in the following tables, the "Coal Bluff," "Fury," "Henry Bosse" and "Alert" are in the first class; the "Ruth," "Mac" and "Grace" in the second; and the "Lucia," "Louise," "Elsie," "Emily" and "Ada" in the third. The "Elsie" was built with a steel hull, and the wooden hull of the "Louise" was changed to steel in 1905.

The "Fury" and "Henry Bosse" (formerly the "Vixen") were built under contract at Dubuque, Iowa. Their hulls are of oak, 100 ft. x 19 ft. 6 in. x 3 ft. 10 in.; cylinders, 10½ in. x 4 ft.; one boiler, 22 ft. x 42 in., with ten 6-in. flues. Both of these boats have been rebuilt with somewhat different dimensions. On December 31, 1910, they were classed as fair, which means that extensive repairs were needed.

The "Alert" was bought second-hand; hull, oak, 115x19x3 ft.; cylinders, 10 in. x 5 ft.; one boiler, 16 ft. x 43 in.; rebuilt in 1884 and partially rebuilt several times. December 31, 1910, in bad condition.

The "Coal Bluff" was bought second-hand, 3 years old; hull, oak, 120 ft. x 22 ft. x 4 ft. 6 in.; cylinders, 15 in. x 5 ft.; three boilers, 25 ft. x 36 in.; hull twice rebuilt and also very large repairs; condition, bad.

The "Mac" was bought nearly new; oak hull, 73x16x3 ft.; cylinders, 7 in. x 3 ft. 2 in.; one boiler, 14 ft. x 36 in.; hull has never been entirely rebuilt, although large repairs were made in 1894, 1902, and 1910; condition, good.

The "Ruth" was built by the United States; hull, oak, 75 ft. x 17 ft. x 3 ft. 3 in.; cylinders, 7 in. x 4 ft.; two boilers, 10 ft. x 30 in.; hull has not been entirely rebuilt, but received large repairs in 1901 and 1909; condition, good.

The "Grace" was built by the United States; hull, oak, 79x17 ft.; cylinders, 7 ft. 6 in. x 4 ft. 1 in.; two boilers, 10 ft. x 30 in.; hull has not been rebuilt or received large repairs; condition, good.

Small Tow-Boats. The "Lucia" was built by the United States at Keokuk; hull, oak, 68 ft. x 12 ft. 8 in. x 3 ft.; cylinders, 6 in. x 2 ft. 6 in.; boiler, 10 ft. x 38 in. She had large repairs in 1892 and 1904, and her hull was rebuilt in 1895 and 1909-1910; condition, December 31, 1910, good.

The "Louise" was built by the United States at Keokuk; hull, oak, 61x12x3 ft.; cylinders, 6 in. x 2 ft. 6 in.; boiler, 10 ft. x 34 in.; hull rebuilt in 1894; steel hull in 1905; moderate repairs each year; condition, good.

The "Elsie" has a steel hull and was built by contract at Jefferson, Ind.; hull, 67x13x3 ft.; cylinders, 6 in. x 2 ft. 6 in.; boiler, 10 ft. x 34 in. The "Elsie" appears to have cost as much money as the wooden hull "Ada" for the same period of time.

The "Emily" was built by the United States at Keokuk; hull, oak, 67x12x3 ft.; cylinders, 6 in. x 2 ft. 4 in.; boiler 10 ft. x 34 in.; condition, good; new hulls in 1902 and 1909-1910.

The "Ada" was built by the United States at Keokuk; hull, oak, 68x11x3 ft.; cylinders, 6 in. x 2 ft. 6 in.; boiler, 10 ft. x 34 in.; condition, good; hull rebuilt 1903-1904.

These small tow-boats are of great value with light tows in working around the dams.

TABLE 154—TOW-BOATS (LARGE AND MEDIUM), OAK HILLS.

	Year	Fury, Built 1881	Henry Bosse, Built 1881	Alert, Built 1874; Rebuilt 1881.	Coal Bluff, Built 1878; Rebuilt 1881	Mac, Built 1891; Rebuilt 1893	Ruth, Built 1895	Grace, Built 1904
Original cost.......	....	$11,976.00	$11,976.00	$ 6,000.00	$ 8,000.00	$ 2,500.00	$ 6,426.47	$8,616.37
Repairs to..........	1890	6,292.71	10,432.01	*14,202.00	*25,769.09	....	....	....
Repairs	1891	‡3,187.09	‡2,032.26	133.32	....	....	....	....
Repairs	1892	426.35	588.95	409.31	‡3,628.02	....	....	....
Repairs	1893	1,973.82	375.52	‡1,586.61	‡2,236.53	653.06	....	....
Repairs	1894	255.93	749.85	‡1,770.12	1,283.67	‡1,379.93	....	....
Repairs	1895	†3,364.32	*5,050.51	559.08	702.83	362.34	....	....
Repairs	1896	2.90	272.45	590.88	215.86	539.22	99.44	....
Repairs	1897	463.70	232.30	‡1,938.49	1,028.62	430.38	159.28	....
Repairs	1898	497.46	200.42	‡1,034.95	72.72	571.35	231.57	....
Repairs	1899	*5,247.28	224.16	‡1,064.78	*9,122.30	400.07	289.95	....
Repairs	1900	147.19	‡1,744.01	191.28	602.44	434.25	397.82	....
Repairs	1901	38.91	231.22	....	223.05	142.09	‡1,112.67	....
Repairs	1902	998.34	629.91	304.47	1,175.51	‡1,862.03	275.00	....
Repairs	1903	495.76	460.44	‡1,619.06	277.86	237.65	338.59	....
Repairs	1904	461.53	523.90	476.68	621.19	195.54	799.11	....
Repairs	1905	583.63	‡3,375.25	692.31	1,612.76	874.04	220.38	119.33
Repairs	1906	1,209.11	61.12	‡1,208.05	858.65	210.01	643.98	28.86
Repairs	1907	‡3,026.34	87.41	‡1,804.35	‡3.204.10	457.66	492.41	225.79
Repairs	1908	337.25	497.52	‡1,574.92	‡3,226.92	631.64	661.29	35.65
Repairs	1909	719.70	695.27	‡1,680.45	280.74	606.00	‡2,881.30	266.00
Repairs	1910	1,178.67	1,210.28	‡2,720.89	‡1,686.93	‡1,927.61	766.30	157.67
Totals	....	$42,883.89	$41,650.76	$41,562.00	$65,829.79	$14,414.87	$15,795.56	$9,449.67

*New hull. †New boilers. ‡Very large repairs to hull.

The total cost of each of the first three boats mentioned in this table appears very small for thirty years' service, and while considering the greatly increased cost of lumber, it may now be advisable to build of steel or iron, it is manifest that wooden hulls in the past were cheaper than metal would have been.

TABLE 155—TOW-BOATS (Small)

	Year	Lucia, Built 1885	Louise, Built 1884	Elsie, Built 1889	Emily, Built 1889	Ada, Built 1889
Original cost	....	$ 4,000.00	$ 3,538.00	$ 5,110.00	$ 4,034.00	$ 4,000.00
Repairs to and including........	1890	1,560.62	761.25	194.89	175.28	112.70
Repairs	1891	27.79	221.47	200.58	17.57	37.29
Repairs	1892	†1,181.67	....	21.91	350.55	16.55
Repairs	1893	152.45	527.41	519.80	60.82	593.18
Repairs	1894	296.10	*3,010.99	387.87	154.74	791.11
Repairs	1895	*2,286.84	399.96	619.02	328.06	730.04
Repairs	1896	331.57	333.86	102.63	48.25	262.94
Repairs	1897	137.51	84.67	227.11	854.42	475.93
Repairs	1898	58.11	96.22	534.62	55.54	557.22
Repairs	1899	142.25	60.10	112.64	86.74	142.20
Repairs	1900	78.64	565.27	35.52	166.64	47.15
Repairs	1901	87.73	....	1.26	....	....
Repairs	1902	156.02	323.20	319.63	*2,908.74	394.54
Repairs	1903	75.07	349.21	87.42	12.10	*1,045.64
Repairs	1904	†1,086.20	259.12	751.60	103.56	*1,583.06
Repairs	1905	44.51	‡2,991.17	266.49	205.28	50.60
Repairs	1906	80.52	326.60	194.43	82.49	136.75
Repairs	1907	453.22	368.42	583.86	410.16	328.19
Repairs	1908	186.60	212.91	807.72	447.80	127.21
Repairs	1909	*1,107.44	62.47	331.29	*850.31	364.00
Repairs	1910	*3,044.29	541.18	1,150.08	*3,123.56	454.30
Totals	....	$15,485.15	$15,033.48	$12,560.37	$14,476.61	$12,250.60

*New hull built. †Large repairs. ‡New hull built, steel.

All of these boats, except the Elsie, had wooden ¾-hulls when built. The Elsie's hull is steel and the Louise has also a steel hull since 1905. The Elsie, Emily and Ada were built in the same year, and the cost of the two latter compares favorably with the former.

UNLOADING MACHINES

(See Steam Shovel Manufacturers.)

Unloader plows, Figs. 307-308, are largely used in railroad and canal construction. The best types are constructed entirely of steel. They are usually operated by being pulled through the train of cars by a cable attached to the engine. Three types are manufactured: the center unloader, which distributes the material equally on both sides of the track; the right unloader, which distributes the material to the right; and the similarly constructed left unloader, which places the material on the left. A right unloader can be used as a left unloader and vice versa, by reversing the direction of the pull.

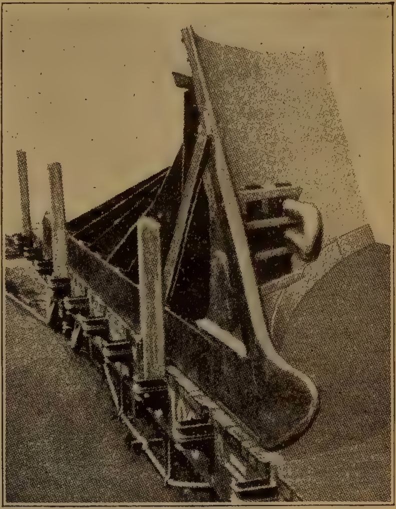

Fig. 307. Type L-4 Bucyrus Side Plow Showing Curve of Moldboard.

Type	Car Capacity, Cu. Yds.	Height of Mould Board, Ins.	Price
Centre unloaders.............	10	38 to 27	$300.00
Centre unloaders.............	20	45 to 33	375.00
Centre unloaders.............	35	58 to 44	550.00
Centre unloaders.............	50	60	700.00
Right or left.................	10	36	300.00
Right or left.................	25	42	375.00
Right or left.................	35	57	525.00
Right or left.................	50	60	650.00

Mr. Gillette says that the time occupied in unloading a train of 12 cars with an unloader plow is from 10 to 30 minutes, the engine doing as much in that time as 8 to 10 men would do in a day. When unloading on curves the time is longer, for snatch blocks must be used to keep the cable on the cars. A snatch block every third car is generally enough. When the plow reaches a snatch block it must be stopped, the block and chain being removed and carried forward. Unloading in this way takes about twice as long as on straight track and often longer.

When much material is to be handled the cars should be rigged with hinged side boards that can be dropped down when unloading, and a hoisting engine should be rigged up on a car by itself for the purpose of pulling the plow cable. A 10 x 12 in. double cylinder engine with a 1-in. cable for loose gravel, and a 1⅛-in. for heavier material will unload a train of cars often in half the time taken by locomotives, since the cars need not be blocked, and the danger of breaking the cable is decreased.

The cost of repairs to unloading plows on the Panama canal work during the 6 months ending June 30, 1910, was for 1,655 days of service, an average of $3.79 per day per plow.

Mr. H. R. Postle in an article in *Engineering-Contracting* of October 12, 1910, describes a device constructed by him for un-

Fig. 308. Bucyrus Left Hand Side Plow at Work on Erie Railroad.

loading crushed stone from railroad cars into dump wagons. By the old method of shoveling, unloading crushed rock ordinarily costs from 20 to 25 cents per ton, with California wages, but by means of this apparatus rock is being unloaded for about one-third to one-half of this amount. The method is to draw the rock over the end of the car through a chute hung to the end of the car and into the wagon by means of an ordinary slip scraper (largest size), to which is attached a ⅝-in. wire cable, connected to hoisting drum, operated by a gasoline engine.

The chute is built of 2-in. lumber and is 6 ft. wide at one end, 5 ft. at the other end and 5 ft. long and is supported by two legs so that it just clears the wagons, allowing them to be driven under or moved ahead. A roller 3 or 4 in. in diameter is mounted on the outer end over which runs the cable drawing the scraper

and against which the scraper falls when dumping. The hoist drum and gas engine are mounted on a low truck so as to be easily moved. The engine is a 10-horsepower gas engine belted to the hoist drum with an 8-in. belt. The hoist drum is 12 in. in diameter and 10 in. wide.

Cars are spotted with the aid of the hoist and the loading is always done at the same spot, as the cars are thus moved more quickly than the apparatus could be moved from car to car.

The cost of this equipment is as follows:

Gas engine, 10 H. P.	$350.00
Hoist drum	125.00
Truck	50.00
Large scraper	10.00
125 ft. of cable	9.00
Pulley block	3.00
Chute (estimated)	5.00
Total	$552.00

About seven-eighths of a car can be unloaded by a scraper by having two or three shovelers shovel the rock away from the sides and farther end when the rock is getting low in the car. From 200 to 250 tons per day can be unloaded for the following costs as per Los Angeles wages for an 8-hour day:

1 foreman	$ 3.50
1 engineman	3.00
2 scraper men	5.00
3 shovelers	6.00
Gasoline, oil, repairs, etc.	2.50
Total	$20.00

This makes a cost of 8c to 10c per ton.

WAGONS

TABLE 156—BOTTOM DUMP WAGONS.

	Yds.	Lbs.	Size of Tires	Wheel-base	Height	Price
Contractors' wagons	½	5,000	3 x1½"	9′ 4″	4′ 8½″	$110.00
Contractors' wagons	½	5,000	4 x ½"	9′ 4″	4′ 8½″	115.00
Contractors' wagons	2	5,000	3 x ½"	9′ 4″	5′ 4 ″	120.00
Contractors' wagons	2	5,000	4 x ½"	9′ 4″	5′ 4 ″	124.50
Contractors' wagons	1½	8,000	4 x ⅝"	9′ 4″	4′ 9 ″	126.00
Contractors' wagons	2	8,500	4 x ⅝"	9′ 4″	5′ 4 ″	131.00
Asphalt wagons with asbestos linings	2½	9,000	3 x ⅝"	9′ 4″	6′ 0 ″	155.00
Asphalt wagons with asbestos linings	2½	9,000	5 x ⅝"	9′ 4″	6′ 0 ″	157.50
Crush stone wagons with half steel lining	3¼	10,000	2½x1 "	9′ 4″	6′ 0 ″	197.50
Dump box for use on wagon gears with 38″ or 42″ bolsters	1½	......	....	....	......	45.00

Extra for steel lining on regular wagon.................................$14.00
Extra for steel and asbestos lining.................................18.80
Extra for separate ½ yd. top box.................................7.00
Extra for separate 1 yd. top box.................................14.00
Extra for brake.................................9.00
Extra for Sarven patent wheels, set.................................4.70

MUNICIPAL WAGONS.

	Yds.	Lbs.	Size of Tires	Wheel-base	Height	Price
Municipal wagons	4	8,500	3x⅝"	11′ 4″	6′ 5″	$164.00
Municipal wagons	3	8,000	3x⅝"	11′ 4″	5′ 8″	150.00
Municipal wagons	†2½	9,500	3x⅝"	11′ 4″	5′ 6″	200.00
Municipal wagons	5	9,500	3x⅝"	11′ 4″	7′ 0″	200.00
Municipal wagons	*3	8,500	3x⅝"	9′ 4″	5′ 11″	153.00

* Is steel lined. † Is an asphalt wagon with asbestos and steel lining. Extra for 4″ tires, $4.50.

REVERSIBLE BOTTOM DUMP WAGONS.

Capacity, 10,000 pounds or 3 cubic yards level. About 3½ cubic yards rounded load per wagon.

4x⅝ inch tires—wood wheels.................$260.00
6x⅝ inch tires—steel wheels.................285.00
8x⅝ inch tires—steel wheels.................309.00

With reasonable use a wagon will last five years. Wagons are usually sold under a six months' guarantee.

For heavy loads tires should be ⅝-in. thick. The difference in cost between a ½-in. and ⅜-in. tire is about $2.50 and the saving in wear and tear is many times this.

Old wagons for a period of twelve months averaged for repairs $3 per month. Original cost $70. New wagons other than dump wagons, original cost $70, averaged $2 for repairs for eighteen months.

Wagon poles of oak, non-ironed, cost $3.60 each. It takes a man about one hour and a half to fit a pole. On rough work a wagon pole lasts about two months; if used on fairly good roads it should last two or three years.

A reversible stone spreading car for use in hauling to, and spreading stone on, macadam roads costs $450. The capacity is 10 tons or from 5 to 8 yards. The double-hinged bottom, operated by crank and chain, allows the stone to spread automatically from 1 to 24 inches deep. It has a swivel truck at each end to admit of its being moved in either direction, a short wheel-base, making it easy to turn short curves. The dimensions are: length of body, 14 ft.; width, 5 ft.; depth, 4 ft.; diameter of wheels, 48 in.; width of tires, 12 in.

A truck of this type may be fitted with a platform, box or other body for hauling heavy freight, etc. The size of traction engine necessary depends on the number of cars in a train, condition and grade of road, length of haul, etc.

The following data are from a report made by the Construction Service Co. of New York on the economic performance of Reversible Dump Wagons of three yards capacity drawn by traction engines as compared with ordinary two-horse 1½ yd. wagons.

The assumed value of the traction drawn plant is as follows:

Item	Value	Life	Dep. Rate per Year	Dep. per Working Day	Int. per Working Day
12—3 yd. wagons	$2,724.72	6 years	16⅔%	$2.60	93c
Engine	2,000.00	15 years	6⅔%	.76	69c
Water tank	300.00	10 years	10 %	.17	10c

The standard cost of operating the same with traction engine is:

Engineer	$ 3.00
Fireman	2.00
Coal for 10 miles, average 1¼ tons, at $2.25	2.82
Repairs	4.30
Depreciation	3.53
Interest	1.72
Liability insurance, say 2% of the payroll	.13
Miscellaneous and superintendence, 20% of the above	3.50
Total expenses per day	$21.00

The assumed value of a horse is $150 and the assumed cost of operating the horse-drawn plant is as follows:

Two horses cost, per day	$3.00
$110.00 wagon, depreciation	.124
Interest	.044
Repairs	.15
Miscellaneous, including harness, etc	.072
Driver	1.50
Insurance, 2% of payroll	.03
Miscellaneous and superintendence, 20%	.98
Total expense per day	$5.90

The assumed working season for the traction-drawn outfit is 7 months of 25 working days or 175 working days per year, whereas, the assumed season of the horse-drawn outfit is 7½ months of 20 working days or 150 working days per year.

The accompanying diagram gives the resultant unit costs for different loads and length of haul.

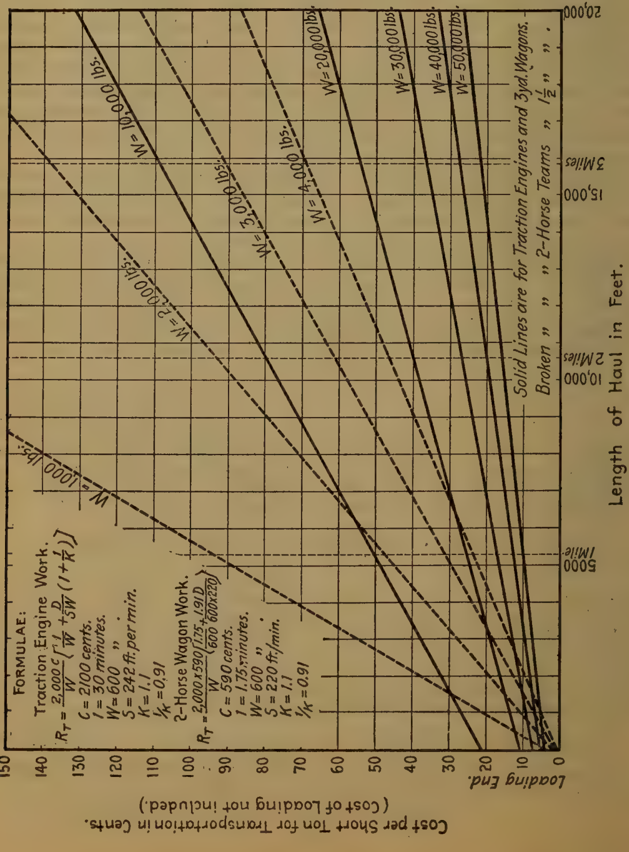

Fig. 309.

Fig. 310. Horse Wagon.

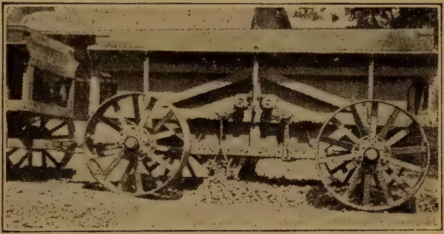

Fig. 311. Traction Wagon. Bottom Dump.

The following table which gives the cost of hauling of various materials in wagons is taken from *Engineering & Contracting.* The average net load is assumed as 3,000 lbs, or 1½ short tons. A good team can readily haul such a load over fair earth roads. An average traveling speed of 2½ miles per hour going loaded and returning empty at a rate of 3½ per 10-hour day for team and driver is assumed. The cost of hauling 1 mile does not include the cost of loading and unloading.

Material	Load (3000 Lbs.)	Cost of Haul, 1 Mile, Cts.
Brick, building (2¼x8¼)	555	50 per M
Brick, paving (2½x8½x4)	444	63 per M
Block, paving (3¼x8½x4)	333	81 per M
Broken sandstone	1.2 cu. yds.	23 per cu. yd.
Broken trap rock	1.1 cu. yds.	25 per cu. yd.
Cement, natural	11 bbls.	2.5 per bbl.
Cement, Portland	7½ bbls.	3.7 per bbl.
Coal	1½ tons	18.6 per ton
Earth	1.2 cu. yds.	23 per cu. yd.
Lime	14 bbls.	2 per bbl.
Rock, granite, solid	0.66 cu. yd.	42 per cu. yd.
Sand, dry	1.1 cu. yd.	25 per cu. yd.
Sewer pipe:		
4 in.	332 lin. ft.	0.084 per lin. ft.
6 in.	200 lin. ft.	0.14 per lin. ft.
8 in.	40 lin. ft.	0.7 per lin. ft.
12 in.	140 lin. ft.	0.2 per lin. ft.
18 in.	66 lin. ft.	0.42 per lin. ft.
Tile, 4 in.	428 lin. ft.	0.065 per lin. ft.
Timber:		
Kiln dried oak	800 ft. B. M.	35 per M. ft.
Kiln dried yellow pine	1000 ft. B. M.	28 per M ft.
Southern yellow pine, green	666 ft. B. M.	42 per M ft.
White oak, green	600 ft. B. M.	46 per M ft.
Water	48 cu. ft.	58 per 100 cu.ft.
Water	360 gals.	0.077 per 100 gal.
Water pipe (cast):		
4 in.	132 lin. ft.	0.21 per lin. ft.
6 in.	84 lin. ft.	0.33 per lin. ft.
8 in.	60 lin. ft.	0.47 per lin. ft.
12 in.	36 lin. ft.	0.77 per lin. ft.
20 in.	12 lin. ft.	2.3 per lin. ft.

WELDING

THERMIT PROCESS.

Thermit is a mixture of finely divided aluminum and iron oxide. When ignited in one spot, the combustion so started continues throughout the entire mass without supply of heat or power from outside and produces superheated liquid steel and superheated liquid slag (aluminum oxide). The thermit reaction produces an exceedingly high temperature, the liquid mass attaining 5,400° Fahrenheit in less than 30 seconds. The liquid steel produced by the reaction represents one-half of the original thermit by weight and one-third by volume.

Welding by the thermit process is accomplished by pouring superheated thermit steel around the parts to be united. Thermit steel, being approximately twice as hot as ordinary molten steel, dissolves the metal with which it comes in contact and amalgamates with it to form a single homogeneous mass when cooled. The essential steps are to clean the sections and remove enough metal to allow for a free flow of thermit steel, surround them with a mold, preheat by means of a gasoline and compressed air torch and then pour the steel. Full directions are supplied by the company owning this process and are not given here on account of the limited space.

The following detailed outfit is suitable for repair work on a small railroad or the equipment of a contractor, where the sections of wrought iron or steel do not exceed 4x6 in. in size:

Item	Price
1 automatic crucible No. 6	$ 16.50
1 double burner thermit preheating torch complete	75.00
1 tapping spade	.50
300-lb. thermit mixed with 1% manganese and 1% nickel thermit and 15% punchings	80.04
10 lbs. yellow wax @ $0.35	3.50
1 bbl. special moulding material for facing	4.00
1 lb. ignition powder	.90
Total cost, f. o. b. Jersey City	$180.34

The preheater is a permanent appliance and will last indefinitely, while the crucible will last from 16 to 20 reactions, after which it may be relined with magnesia tar in the field or at the factory for $11.50. Each crucible requires 141 lbs. tar at 3 cents per lb., and one magnesia stone. No construction equipment is required except that it will be necessary to make a mold box out of sheet iron. Five extra packages of plugging material and four extra thimbles are supplied with each new crucible. Extra packages and thimbles cost 10 cents each.

The prices of other sizes of appliances are as follows:

Item	Price	Weight (Lbs.)
Preheater torch, single burner	$50.00	175
Preheater torch, double burner	75.00	200
Automatic crucible, No. 1, for 6 lbs. thermit	3.50	40
Automatic crucible, No. 2, for 8 lbs. thermit	5.50	60
Automatic crucible, No. 3, for 15 lbs. thermit	6.50	110
Automatic crucible, No. 4, for 25 lbs. thermit	8.00	125
Automatic crucible, No. 5, for 35 lbs. thermit	11.00	150
Automatic crucible, No. 6, for 70 lbs. thermit	16.50	225
Automatic crucible, No. 7, for 140 lbs. thermit	30.00	385
Automatic crucible, No. 8, for 210 lbs. thermit	35.00	480
Automatic crucible, No. 9, for 280 lbs. thermit	43.50	580
Automatic crucible, No. 10, for 400 lbs. thermit	55.00	720
*Tripods, No. 1	2.10	11
*Tripods, Nos. 2-3	2.50	19
*Tripods, Nos. 4-5	3.00	24
*Tripods, Nos. 6-7	5.50	65
*(For welding connecting rods and driving wheel spokes, etc.)		
Flat bottom crucibles, No. 2, for 4 lbs. thermit	1.75	18
Flat bottom crucibles, No. 3, for 8 lbs. thermit	3.00	27
Flat bottom crucibles, No. 4, for 16 lbs. thermit	4.75	65
Flat bottom crucibles, No. 5, for 40 lbs. thermit	7.00	95
Tongs for flat bottom crucible, No. 2	2.00	6½
Tongs for flat bottom crucible, No. 3	2.50	17½
Tongs for flat bottom crucible, No. 4	3.25	25
Tongs for flat bottom crucible, No. 5	4.50	30½
Cost of relining flat bottom crucible, No. 2	.75	
Cost of relining flat bottom crucible, No. 3	1.25	
Cost of relining flat bottom crucible, No. 4	2.50	
Cost of relining flat bottom crucible, No. 5	4.00	
Thermit (sold only in 50 lb. boxes).		
50-lb. drum	12.50	55½
100-lb. drum	25.00	110
Thermit with 1% manganese and 1% nickel thermit.		
50-lb. drum	13.15	56½
100-lb drum	26.30	112
Ignition powder, ½-lb. cans	.45	
Metallic manganese, per lb	.75	
Nickel thermit, per lb	.55	
Yellow wax, per lb	.35	
Special moulding material, per bbl	4.00	340

The proper quantity of thermit required for the weld may be calculated by multiplying by 32 the weight of the wax necessary to fill all parts of the fracture and reinforcement, or else by calculating the number of cu. in. in the fracture and reinforcement and allowing one pound of thermit mixed with the necessary additions, to the cubic inch. If more than 10 lbs. of thermit are to be used it is necessary to mix steel punchings, not exceeding ½-in. in diameter, into the powder. For 10 lbs. or more of thermit 10% of punchings should be added; for 50 lbs. or more 15% of small mild steel rivets should be mixed in. 1% each of manganese and nickel thermit should be added also.

WHEELBARROWS

Wheelbarrows and carts equipped with self-lubricating or roller bearing wheel.

TABLE 157.

Trade Name	Description	Cap. Each (Cu. Ft.)	Wt. per Doz. Lbs.	Price per Doz. 16 Gauge Tray	Price per Doz. 14 Gauge Tray
Forward dump	Steel tray, legs, wheels, wood handles...	4½	780	$45.00	$51.00
Acme forward dump	All steel with tubular framing.........	4	800	68.00	74.00
Panhandle	Steel tray and wheels, wood handles and legs	3	600	38.00	44.00
Sterling concrete barrow	Steel tray, legs and wheels, wood handles	3½	720	42.00	38.00
Sterling concrete barrow	Steel tray, legs and wheels, extended wood handles for forward dump......	3½	780	45.00	51.00
Eureka concrete barrow	Deep steel tray, legs and wheel, wood handles, extended forward dump.....	3*	900	51.00	
Sterling concrete barrow	Steel tray, legs and wheels, extended wood handles for forward dump.....	4½	900	48.00	54.00
Sterling concrete barrow	Deep steel tray, legs and wheel, extended wood handles......................	3*	960	54.00	60.00
Tubular steel mining barrow	All steel with continuous steel tubular handles	3	800	45.00	51.00
Tubular steel mining barrow	All steel with continuous steel tubular handles, extra strong................	3½	900	48.00	54.00
Tubular steel mining barrow	All steel with continuous steel tubular handles, deep tray	4	960	51.00	57.00
Ajax concrete barrow	All steel, continuous tubular handles....	3*	900	54.00	60.00
Baker's concrete conveyor	All steel, forward dump................	3*	960		90.00
Hewett special foundry barrow	Same as Acme, but strongly reinforced..	1000 lbs.	1140		96.00
Sterling coal barrow	All steel, extra large tray.............	6	1100		84.00
Sterling pig iron barrow	All steel, high platform barrow........	1000 lbs.	1260		60.00
Sterling stone barrow	All steel, low platform barrow.........	500 lbs.	1140		60.00
Garden barrow	Wood handles, steel legs, wheel and tray			45.00	
Sterling concrete cart No. 0	All steel, 30" wheels, 2 legs...........	4½	2040		180.00
Same as No. 1	All steel, 30" wheels, 2 legs...........	7	2400		192.00
Same as No. 3	Extra heavy	7	2400		198.00
Perfection concrete cart		7	2520		240.00
Pig iron trucks	Wood bed, rest steel 2-21" wheels, 3-7" and guide wheels....................	2000 lbs.	2760		288.00

For price of No. 12 gauge tray add $6 to 14 gauge list. * Indicates that this is the guaranteed capacity when loaded with wet sloppy concrete. The capacities without the star mean dry measure.

Wooden Wheelbarrows. Net prices at Chicago for wooden wheelbarrows in quantities are as follows: Full bolted wooden railroad wheelbarrows, with heavy steel wheel, 16½ in. in diameter, sell at \$1.75 to \$1.85 each, or \$18.00 to \$19.75 per doz. Bolted wooden mortar barrows, weighing 60 lbs. each, with tight box, 10 in. deep at handles and 13 in. at wheel, sell at \$2.75 each, or \$27.50 per doz. Bent handled wooden stone barrows can be bought at \$3.25 to \$3.50 each, or \$35.00 to \$40.75 per doz. Folding wooden barrows, with removable sideboards and

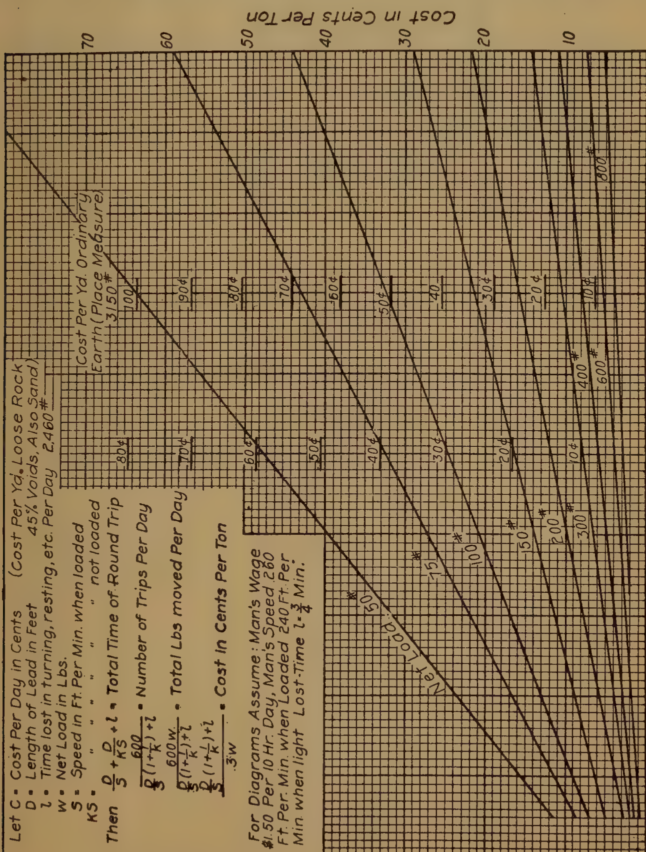

Fig. 312. Transportation by Wheelbarrow.

double frames, 4 cu. ft. capacity, sell at $3 each, or $32.50 per doz.

Some wooden wheelbarrows which cost originally $21 per doz. had a life of 6 months in rock work and about 1 year in earth work; they would last still longer in concrete, this being for single shift work. The average cost of repairs was 30 cts. per month per barrow.

It was found that wheelbarrows with steel trays, iron wheels and wooden frames had about the same total life but the average cost for repairs was 20 cts. per month.

A dozen wooden frame barrows with steel wheels and steel trays costing $30 per doz. were useless in 6 months in work 80 per cent of which was rock and 20 per cent earth. Total repairs for these 6 months amounted to $10, or 14 cts. per barrow per month. Eighteen wheelbarrows costing $60 per doz. were bought, one of which survived 6 months of the same kind of work. The cost of renewing trays for these was $1 per wheelbarrow for the 6 months and general repairs amounted to $30, or 28 cts. per barrow per month. Of another dozen costing $27 with wooden trays and steel wheels 10 survived 6 months' work at a total cost for repairs of $28, or 39 cts. per barrow per month.

APPENDIX

CLASSIFIED LIST OF CONSTRUCTION PLANT MANUFACTURERS AND DEALERS

APPENDIX

AIR COMPRESSORS.

Abenaque Machine Works, Westminster Station, Vt.
Allis-Chalmers Co., Milwaukee, Wis,
American Well Works, Aurora, Ill,
Blaisdell Machinery Co., Bradford, Pa.
Blake & Knowles Steam Pump Co., New York, N. Y.
Chicago Pneumatic Tool Co., Chicago, Ill.
Dallett Co., Thos. H., Philadelphia, Pa.
Dean Bros. Steam Pump Co., Indianapolis, Ind.
DeLaval Steam Turbine Co., East Trenton, N. J.
Fairbanks, Morse & Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Goulds Manufacturing Co., Seneca Falls, N. Y.
Ingersoll-Rand Co., New York, N. Y.
McGowan Co., John H., Cincinnati, O.
McKiernan-Terry Drill Co., New York, N. Y.
National Brake & Electric Co., Milwaukee, Wis.
Sullivan Machinery Co., Chicago, Ill.
Waterworks Equipment Co., New York, N. Y.
Westinghouse Air Brake Co., Pittsburgh, Pa.

ASBESTOS.

Asbestos Protected Metal Co., Canton, Mass.
Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York, N. Y.
Keasbey & Mattison Co., Ambler, Pa.

ASPHALT.

Baker, Jr., John, Chicago, Ill.
Barber Asphalt Paving Co., Philadelphia, Pa.
Barrett Manufacturing Co., New York, N. Y.
Byerly & Sons, Cleveland, O.
Gulf Refining Co., Pittsburgh, Pa.
Hercules Oil Refining Co., Los Angeles, Cal.
Indian Refining Co., Pittsburgh, Pa.
Sicilian Asphalt Paving Co., New York, N. Y.
Standard Asphalt & Rubber Co., Chicago, Ill.
Texas Co., New York, N. Y.
Trinidad Asphalt & Manufacturing Co., St. Louis, Mo.
Union Oil Co. of California, Los Angeles, Cal.
United States Asphalt & Rubber Co., New York, N. Y.
Wadsworth Stone & Paving Co., Pittsburgh, Pa.
Warner-Quinlan Co., Cleveland, O.
Warren Bros. Co., Boston, Mass.

ASPHALT PLANTS.

Atlas Dryer Co., Cleveland, O.
Barber Asphalt Paving Co., Philadelphia, Pa.
Cummer & Son, F. D., Cleveland, O.
East Iron & Machine Co., Lima, O.
Hetherington & Berner Co., Indianapolis, Ind.
Iroquois Iron Works, Buffalo, N. Y.
Link-Belt Co., Chicago, Ill.
Ruggles-Coles Engineering Co., New York, N. Y.
Union Iron Works, Hoboken, N. J.

AUTOMOBILES—MOTOR TRUCKS.

Chicago Pneumatic Tool Co., Chicago, Ill.
Garford Motor Truck Co., Toledo, O.
International Harvester Co., Chicago, Ill.

International Motor Truck Co., New York, N. Y.
Jeffery Co., Thos. B., Kenosha, Wis.
Kelly-Springfield Motor Truck Co., Springfield, O.
Kissel-Kar Co., Milwaukee, Wis.
Packard Motor Car Co., Detroit, Mich.
Peerless Motor Car Co., Cleveland, O.
Pierce-Arrow Motor Car Co., Buffalo, N. Y.
Reo Motor Car Co., Lansing, Mich.
Speedwell Motor Car Co., Dayton, O.
Tiffin Wagon Co., Tiffin, O.

BAR BENDERS.

Chicago Builders Specialty Co., Chicago, Ill.
Electric Welding Co., Pittsburgh, Pa.
Hanson & Sons, A. P., Chicago, Ill.
Hinman & Co., D. A., Sandwich, Ill.
Kardong Bros., Minneapolis, Minn.
Koehring Machine Co., Milwaukee, Wis.
Marsh-Capron Manufacturing Co., Chicago, Ill.
McKenna Co., Cleveland, O.
Ransome Concrete Machinery Co., Dunellen, N. J.
Union Machinery Co., St. Paul, Minn.
Wallace Supply Co., Chicago, Ill.
Wiener Machinery Co., New York, N. Y.

BAR CUTTERS.

Braun, J. G., Chicago, Ill.
Buffalo Forge Co., Buffalo, N. Y.
Mersick & Co., C. S., New Haven, Conn.
Pels & Co., Henry, Albany, N. Y.
Rock River Machine Co., Janesville, Wis.
Waterbury Farrel Foundry & Machinery Co., Waterbury, Conn.
Watson-Stillman Co., New York, N. Y.
Wiener Machinery Co., New York, N. Y.

BARGES AND SCOWS.

American Bridge Co., New York, N. Y.
American Car & Foundry Co., St. Louis, Mo.
Carroll-Porter Boiler & Tank Co., Pittsburgh, Pa.
Chicago Bridge & Iron Works, Chicago, Ill.
Jones & Laughlin Steel Co., Pittsburgh, Pa.
Pittsburgh-Des Moines Bridge & Iron Works, Pittsburgh, Pa.
Skinner Ship Building Co., Baltimore, Md.
Union Iron Works, San Francisco, Cal.

BLASTING APPARATUS.

Batteries—Blasting.

American Carbon & Battery Co., St. Louis, Mo.
Du Pont de Nemours Powder Co., E. I., Wilmington, Del.
McAbee Powder & Oil Co., P. R., Pittsburgh, Pa.
National Carbon Co., Cleveland, O.
Star Electric Fuse Works, Wilkes-Barre, Pa.
Western Electric Co., Chicago, Ill.

Blasting Machines.

Aetna Powder Co., Chicago, Ill.
Du Pont de Nemours Powder Co., E. I., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.
Ingersoll-Rand Co., Chicago, Ill.
Western Electric Co., Chicago, Ill.

Fuse Caps.

Aetna Powder Co., Chicago, Ill.
Independent Powder Co. of Missouri, Joplin, Mo.

McAbee Powder & Oil Co., P. R., Pittsburgh, Pa.
Metallic Cap Manufacturing Co., New York, N. Y.
Rendrock Powder Co., New York, N. Y.

Kettles for Thawing.

Du Pont de Nemours Powder Co., E. I., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.

(Explosives, see under "Dynamite.")

BINS—PORTABLE.

Good Roads Machinery Co., Kennett Square, Pa.
Weller Manufacturing Co., Chicago, Ill.

BINS—STORAGE.

Brown Hoisting Machinery Co., Cleveland, O.
Jeffrey Manufacturing Co., Columbus, O.
Ransome Concrete Machinery Co., Dunellen, N. J.
Raymond Concrete Pile Co., New York and Chicago.
Weller Manufacturing Co., Chicago, Ill.

BLOCKS—TACKLE.

American Hoist & Derrick Co., St. Paul, Minn.
Bond Co., Harold L., Boston, Mass.
Boston & Lockport Block Co., Boston, Mass.
Boston Selflocking Block Co., Boston, Mass.
Broderick & Bascom Rope Co., St. Louis, Mo.
Burr Manufacturing Co., Cleveland, O.
Byers Machine Co., John F., Ravenna, O.
Cleveland Block Co., Cleveland, O.
Clyde Iron Works, Duluth, Minn.
Columbia Steel Co., Portland, Me.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Cottington & Son, J. C., Philadelphia, Pa.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Donahue & Co., J. T., Baltimore, Md.
Edwards & Co., H D., Detroit, Mich.
Eureka Tackle Block Manufacturing Co., Cincinnati, O.
Hartz Co., H. V., Cleveland, O.
Leschen & Sons Rope Co., A., St. Louis, Mo.
Lidgerwood Manufacturing Co., New York, N. Y.
Lupkin, P. E., Gloucester, Mass.
Merriman Bros. Co., Boston, Mass.
Patterson, W. W., Pittsburgh, Pa.
Pittsburgh Block & Manufacturing Co., Pittsburgh, Pa.
Roebling's Sons Co., John A., New York, N. Y.
Stowell Manufacturing & Foundry Co., South Milwaukee, Wis.
Terry & Tench Co., New York, N. Y.
Union Elevator Machine Co., Chicago, Ill.
Walsh Sons & Co., Harrison, N. J.

BLUE PRINT FRAMES.

American Drafting Furniture Co., Rochester, N. Y.
Dietzgen Co., Eugene, Chicago, Ill.
Elliott Co., B. K., Pittsburgh, Pa.
Fritz Manufacturing Co., Grand Rapids, Mich.
Keuffel & Esser Co., New York, N. Y.
Post Co., Frederick, Chicago, Ill.
Shaw Blue Print Machine Co., Newark, N. J.
Soltmann Co., E. G., New York, N. Y.

BLUE PRINT MACHINES.

American Drafting Furniture Co., Rochester, N. Y.
Buckeye Engineering Co., Salem, O.
Buffalo Blue Print Co., Buffalo, N. Y.

Elliott Co., B. K., Pittsburgh, Pa.
Paragon Machine Co., Rochester, N. Y.
Pease Co., C. F., Chicago, Ill.

BOILERS.

Abendroth & Root Manufacturing Co., Newburgh, N. Y.
American Radiator Co., Chicago, Ill.
Babcock & Wilcox Co., New York, N. Y.
Beggs & Co., James, New York, N. Y.
Brennan & Co., John, Detroit, Mich.
Brownell Co., Dayton, O.
Byers Co., John F., Ravenna, O.
Carroll-Porter Boiler & Tank Co., Pittsburgh, Pa.
Casey-Hedges Co., Chattanooga, Tenn.
Clyde Iron Works, Duluth, Minn.
Connelly Boiler Co., D., Cleveland, O.
Fairbanks, Morse & Co., Chicago, Ill.
Farquhar Co., A. B., York, Pa.
Frick Co., Waynesboro, Pa.
Johnston Bros., Ferrysburg, Mich.
Keeler Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Kittoe Boiler & Tank Co., Canton, O.
Lake Erie Boiler Works, Buffalo, N. Y.
Lidgerwood Manufacturing Co., New York, N. Y.
MacKinnon Boiler & Machine Co., Bay City, Mich.
Oil Well Supply Co., Pittsburgh, Pa.
Petroleum Iron Works, Sharon, Pa.
Power & Mining Machinery Co., Cudahy, Wis.
Struthers-Wells Co., Warren, Pa.
Union Iron Works, San Francisco, Cal.
Warren City Tank & Boiler Co., Warren, O.

BOOTS.

Bates & Co., J. E., New York, N. Y.
Goodrich Co., B. F., Akron, O.
Mulconroy Co., Philadelphia, Pa.
Putnam Co., H. J., Minneapolis, Minn.
Rubberhide Co., Boston, Mass.

BUCKETS—BOTTOM DUMP.

Acme Equipment & Engineering Co., Cleveland, O.
Atlas Car & Manufacturing Co., Cleveland, O.
Biehl Iron Works, Reading, Pa.
Cockburn Co., Jersey City, N. J.
Hunt Co., C. W., West New Brighton, N. Y.
Insley Manufacturing Co., Indianapolis, Ind.
Lakewood Engineering Co., Cleveland, O.
Link-Belt Co., Chicago, Ill.
McMyler Interstate Co., Bedford, O.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Ransome Concrete Machinery Co., Dunellen, N. J.
Stuebner Iron Works, G. L., Long Island City, N. Y.
Tide Water Iron Works, Hoboken, N. J.
Union Iron Works, Hoboken, N. J.
Williams Co., G. H., Cleveland, O.

BUCKETS—CONCRETE.

Acme Equipment & Engineering Co., Cleveland, O.
Bond Co., Harold L., New York, N. Y.
Brown Hoisting Machinery Co., Cleveland, O.
Easton Car & Construction Co., Cleveland, O.
Haiss Mfg. Co., Geo., Easton, Pa.
Hayward Co., New York, N. Y.

Insley Manufacturing Co., Indianapolis, Ind.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Lakewood Engineering Co., Cleveland, O.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Ransome Concrete Machinery Co., Dunellen, N. J.
Smith Co., T. L., Milwaukee, Wis.
Stuebner Iron Works, G. L., Long Island City, N. Y.
Union Iron Works, Hoboken, N. J.
Standard Scale & Supply Co., Chicago, Ill.

BUCKETS—GRAB.

Andresen & Evans, Chicago, Ill.
Brosius, Edgar E., Pittsburgh, Pa.
Browning Co., Cleveland, O.
Haiss Manufacturing Co., Geo., New York, N. Y.
Hayward Co., New York, N. Y.
Industrial Iron Works, Bay City, Mich
Kiesler Co., J. F., Chicago, Ill.
Lakewood Engineering Co., Cleveland, O.
Link-Belt Co., Chicago, Ill.
McKenna Co., Cleveland, O.
McMyler Interstate Co., Bedford, O.
Mead-Morrison Manufacturing Co., East Boston, Mass.
Orton & Steinbrenner Co., Chicago, Ill.
Owen Bucket Co., Cleveland, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Rochester Excavation Co., Rochester, N. Y.
Smith & Sons Co., Thos., Jersey City, N. J.
Williams Co., G. H., Cleveland, O.

BUCKETS—SCRAPER.

Bucyrus Co., Milwaukee, Wis.
Dull Co., Raymond W., Chicago, Ill.
Hayward Co., New York, N. Y.
Indianapolis Cable Excavator Co., Indianapolis, Ind.
Insley Manufacturing Co., New York, N. Y.
Lidgerwood Manufacturing Co., New York, N. Y.
Mansfield Engineering Co., Indianapolis, Ind.
Marion Steam Shovel Co., Marion, O.
Monighan Machinery Co., Chicago, Ill.
Page Engineering Co., Chicago, Ill.
Sauerman Bros, Chicago, Ill.

CABLEWAYS.

American Steel & Wire Co., Chicago, Ill.
Dull Co., Raymond W., Chicago, Ill.
Horton, John T., New York, N. Y.
Indianapolis Cable Excavator Co., Indianapolis, Ind.
Lidgerwood Manufacturing Co., New York, N. Y.
Mansfield Engineering Co., Indianapolis, Ind.
Page Engineering Co., Chicago, Ill.
Sauerman Bros., Chicago, Ill.

CARS—BALLAST.

American Car & Foundry Co., St. Louis, Mo.
Continental Car & Equipment Co., Louisville, Ky.
Fairbanks, Morse & Co., Chicago, Ill.
Goodwin Car Co., Chicago, Ill.
Hicks Locomotive & Car Works, Chicago, Ill.
Pressed Steel Car Co., Pittsburgh, Pa.
Rodger Ballast Car Co., Chicago, Ill.
Standard Steel Car Co., Butler, Pa.
Western Wheeled Scraper Co., Aurora, Ill.
Youngstown Car & Manufacturing Co., Youngstown, O.

CARS—DUMP.

American Car & Foundry Co., St. Louis, Mo.
American Clay Machinery Co., Bucyrus, O.
Atlas Car & Manufacturing Co., Cleveland, O.
Austin Manufacturing Co., Chicago, Ill.
Central Locomotive & Car Works, Chicago, Ill.
Chase Foundry Co., Columbus, O.
Continental Car & Equipment Co., Louisville, Ky.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Easton Car & Construction Co., Easton, Pa.
Electric Locomotive & Car Co., West Park, O.
Goodwin Car Co., Chicago, Ill.
Kilbourne & Jacobs Co., Columbus, O.
Lakewood Engineering Co., Cleveland, O.
Link-Belt Co., Chicago, Ill.
National Dump Car Co., Chicago, Ill.
Oliver Manufacturing Co., Wm. J., Knoxville, Tenn.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Steubner Iron Works, Long Island City, N. Y.
Union Iron Works, Hoboken, N. J.
Western Wheeled Scraper Co., Aurora, Ill.
Youngstown Car & Manufacturing Co., Youngstown, O.

CARS—FLAT.

American Car & Foundry Co., St. Louis, Mo.
Atlas Car & Equipment Co., Cleveland, O.
Baltimore Steel Car & Foundry Co., Baltimore, Md.
Chase Foundry Co., Columbus, O.
Continental Car & Equipment Co., Louisville, Ky.
Hunt Co., C. W., West New Brighton, N. Y.
Kilbourne & Jacobs Co., Columbus, O.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Ralston Steel Car Co., Columbus, O.
Rodger Ballast Car Co., Chicago, Ill.
Russell Wheel & Foundry Co., Detroit, Mich.
Stuebner Iron Works, G. L., Long Island City, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.
Youngstown Car & Manufacturing Co., Youngstown, O.

CARS—INSPECTION.

Buda Co., Chicagc, Ill.
Chicago Pneumatic Tool Co., Chicago, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Kalamazoo Railway Supply Co., Kalamazoo, Mich.
Mudge & Co., Chicago, Ill.
Sheffield Car Co., Three Rivers, Mich.

CARS—SPREADER.

Buffalo Pitts Co., Buffalo, N. Y.
Central Locomotive & Car Works, Chicago, Ill.
Continental Car & Equipment Co., Louisville, Ky.
Mann-McCann Co., Chicago, Ill.
Oliver Manufacturing Co., Wm. J., Knoxville, Tenn.
Western Wheeled Scraper Co., Aurora, Ill.

CARTS—CONCRETE.

Acme Equipment & Engineering Co., Cleveland, O.
Atlas Car & Manufacturing Co., Cleveland, O.
Biehl Iron Works, Reading, Pa.
Bond Co., Harold L., Boston, Mass.
Chicago Concrete Machinery Co., Chicago, Ill.
Donahue & Co., John A., Chicago, Ill.
Hunt Co., C. W., New West Brighton, N. Y.
Insley Manufacturing Co., Indianapolis, Ind.
Kentucky Wagon Manufacturing Co., Louisville, Ky.
Kilbourne & Jacobs Co., Columbus, O.
Koehring Machine Co., Milwaukee, Wis.

Lakewood Engineering Co., Cleveland, O.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Milwaukee Concrete Mixer Co., Milwaukee, Wis.
Ransome Concrete Machinery Co., Dunellen, N. J.
Smith Co., T. L., Milwaukee, Wis.
Standard Scale & Supply Co., Chicago, Ill.
Sterling Wheelbarrow Co., Milwaukee, Wis.

CARTS—DUMPING.

Auburn Wagon Co., Martinsburg, W. Va.
Baker Manufacturing Co., Springfield, Ill.
Kentucky Wagon Manufacturing Co., Louisville, Ky.
Kilbourne & Jacobs Co., Columbus, O.
Lansing Co., Lansing, Mich.
Oshkosh Manufacturing Co., Oshkosh, Wis.
Ransome Concrete Machinery Co., Dunellen, N. J.
Schuttler Co., Peter, Chicago, Ill.
Streich & Bro. Co., A., Oshkosh, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

CEMENT TESTING APPARATUS.

Abbe Engineering Co., New York, N. Y.
Bausch & Lomb Optical Co., Rochester, N. Y.
Beach-Russ Co., New York, N. Y.
Clark & Mills Electric Co., Cambridge, Mass.
Eimer & Amend, New York, N. Y.
Fairbanks, Morse & Co., Chicago, Ill.
International Instrument Co., Cambridge, Mass.
Kirschbaum, Lester B. S., Chicago, Ill.
Olsen, Tinius, Co., Philadelphia, Pa.
Reihle Bros., Philadelphia, Pa.

CHAIN HOISTS.

American Hoist & Derrick Co., St. Paul, Minn.
Chisholm & Moore, Cleveland, O.
Cleveland Punch & Shear Co., Cleveland, O.
Dake Engine Co., Grand Haven, Mich.
Detroit Hoist & Machinery Co., Detroit, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Fairbanks, Morse & Co., Chicago, Ill.
Frevert Machinery Co., New York, N. Y.
Godfrey Keeler Co., New York, N. Y.
Jeffrey Manufacturing Co., Columbus, O.
Patterson, W. W., Pittsburgh, Pa.
Pittsburgh Block Manufacturing Co., Pittsburgh, Pa.
Ryerson & Son, J. T., Chicago, Ill.
Yale & Towne Mfg. Co., New York, N. Y.

CHAINS.

Columbus Chain Co., Columbus, O.
Hayden-Corbett Chain Co., Columbus, O.
Jones & Laughlin, Pittsburgh, Pa.
Standard Chain Co., Pittsburgh, Pa.
Taylor Chain Co., Chicago, Ill.
Webster Manufacturing Co., Tiffin, O.
Woodhouse Chain Works, Trenton, N. J.

CHUTES—BROKEN STONE, GRAVEL AND SAND.

Archer Iron Works, Chicago, Ill.
Chain Belt Co., Milwaukee, Wis.
Jeffrey Manufacturing Co., Columbus, O.
Lansing Co., Lansing, Mich.
Link-Belt Co., Chicago, Ill.
Littleford Bros., Cincinnati, O.
Pittsburgh-Des Moines Bridge & Iron Works, Pittsburgh, Pa.
Sackett Chute & Screen Co., Chicago, Ill.
Webster Manufacturing Co., Tiffin, O.

CHUTES—CAR-UNLOADING.

Littleford Bros, Cincinnati, O.
Quick Unloading Car Chute Co., Birmingham, Ala.
Southern Foundry Co., Owensboro, Ky.

CHUTES—CONCRETE.

Archer Iron Works, Chicago, Ill.
Chain Belt Co., Milwaukee, Wis.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago, Ill.
Insley Manufacturing Co., Indianapolis, Ind.
Lakewood Engineering Co., Cleveland, O.
Link-Belt Co., Chicago, Ill.
Pneumatic Concrete Placing Co., Chicago, Ill.
Ransome Concrete Machinery Co., Dunellen, N. J.
Sackett Screen & Chute Co., Chicago, Ill.
Wylie Co., J. S., Chicago, Ill.

CLOTHING—RUBBER.

American Rubber Co., Boston, Mass.
Chicago Rubber Clothing Co., Chicago, Ill.
Goodrich Co., B. F., Akron, O.
Goodyear Tire Co., Akron, O.

CONCRETE MIXERS.

American Cement Machinery Co., Keokuk, Ia.
Archer Iron Works, Chicago, Ill.
Ashland Steel Range Co., Ashland, O.
Atlas Engineering Co., Milwaukee, Wis.
Badger Concrete Mixer Co., Milwaukee, Wis.
Blystone Manufacturing Co., Cambridge Springs, Pa.
Cement Tile Machinery Co., Waterloo, Ia.
Chain Belt Co., Milwaukee, Wis.
Clover Leaf Concrete Machinery Co., South Bend, Ind.
Cream City Equipment Co., Milwaukee, Wis.
Eureka Machinery Co., Lansing, Mich.
Excelsior Mixer & Machinery Co., Milwaukee, Wis.
Foote Concrete Machinery Co., Nunda, N. Y.
Hains Concrete Machinery Co., New York.
Ideal Concrete Machinery Co., Cincinnati, O.
Kent Machine Co, The, Kent, O.
Knickerbocker Co., Jackson, Mich.
Koehring Machine Co., Milwaukee, Wis.
Lakewood Engineering Co., Cleveland, O.
Lansing Co., Lansing, Mich.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Milwaukee Concrete Mixer Co., Milwaukee, Wis.
Municipal Engineering & Contracting Co., Chicago, Ill.
Oshkosh Manufacturing Co., Oshkosh, Wis.
Power & Mining Machinery Co., Cudahy, Wis.
Raber & Lang Manufacturing Co., Kendallville, Ind.
Ransome Concrete Machinery Co., Dunellen, N. J.
Schaefer Manufacturing Co., Berlin, Wis.
Smith Co., T. L., Milwaukee, Wis.
Standard Scale & Supply Co., Chicago, Ill.
Twentieth Century Mixer Co., Connersville, Ind.
Universal Road Machinery Co., Kingston, N. Y.
Van Duzen, Roys & Co., Columbus, O.
Waterloo Cement Machinery Corporation, Waterloo, Ia.
Whitman Agricultural Co., St. Louis, Mo.

CONCRETE SIDEWALK CURB FORMS.

Blaw Steel Construction Co., Pittsburgh, Pa.
Hotchkiss Lock Metal Form Co., Binghamton, N. Y.
Littleford Bros., Cincinnati, O.

CONCRETE SIDEWALK TOOLS.

Anderson Tool Supply Co., Detroit, Mich.
Arrowsmith Concrete Tool Co., Arrowsmith, Ill.
Bond Co., Harold L., Boston, Mass.
Century Manufacturing Co., Chicago Heights, Ill.
Crescent Novelty Co., St. Louis, Mo.
Duffy Manufacturing Co., Chicago, Ill.
Lansing Co., Lansing, Mich.
Ransome Concrete Machinery Co., Dunellen, N. J.
Standard Scale & Supply Co., Chicago, Ill.
Waterloo Cement Machinery Co., Waterloo, Ia.

CONVEYING MACHINERY.

Bartlett & Snow Co., C. O., Cleveland, O.
Brown Hoisting Machinery Co., Cleveland, O.
Caldwell Co., H. W., Chicago, Ill.
Chain Belt Co., Milwaukee, Wis.
Dull Co., Raymond W., Chicago, Ill.
Guarantee Construction Co., New York, N. Y.
Jeffrey Manufacturing Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
Ohio Locomotive Crane Co., Bucyrus, O.
Orton & Steinbrenner Co., Chicago, Ill.
Robins Belt Conveying Co., New York, N. Y.
Union Iron Works, Hoboken, N. J.
Weller Manufacturing Co., Chicago, Ill.

CONVEYORS—BELT.

Beaumont Co., R. H., Philadelphia, Pa.
Green Engineering Co., Chicago, Ill.
Guarantee Construction Co., New York, N. Y.
Hunt Co., C. W., West New Brighton, N. Y.
Jeffrey Manufacturing Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
Robins Belt Conveying Co., New York, N. Y.
Stephens-Adamson Co., Aurora, Ill.
Weller Manufacturing Co., Chicago, Ill.

CONVEYORS—PORTABLE.

Jeffrey Manufacturing Co., Columbus, O.
Page Engineering Co. (Cantilever), Chicago, Ill.
Robins Conveying Belt Co., New York, N. Y.
Weller Manufacturing Co., Chicago, Ill.

CRANES—LOCOMOTIVE.

American Hoist & Derrick Co., St. Paul, Minn.
Atlas Car & Manufacturing Co., Cleveland, O.
Brown Hoisting Machinery Co., Cleveland, O.
Browning Co., Cleveland, O.
Exeter Machine Works, Pittston, Pa.
Industrial Iron Works, Bay City, Mich.
Jeffrey Manufacturing Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
McMyler Interstate Co., Bedford, O.
Maine Electric Co., Portland, Me.
Neumeyer & Dimond, New York, N. Y.
Northern Engineering Works, Detroit, Mich.
Ohio Locomotive Crane Co., Bucyrus, O.
Orton & Steinbrenner Co., Chicago, Ill.

CRUSHERS.

Acme Road Machinery Co., Frankfort, N. Y.
Allis-Chalmers Co., Milwaukee, Wis.
Austin Western Road Machinery Co., Chicago, Ill.
Austin Manufacturing Co., Chicago, Ill.
Bacon, Earle C., New York, N. Y.

Buchanan Co., C. G., New York, N. Y.
Case Threshing Machine Co., J. I., Racine, Wis.
Coldwell-Wilcox Co., Newburgh, N. Y.
Cresson-Morris Co., Philadelphia, Pa.
Eureka Stone & Ore Crusher Co., Cedar Rapids, Mich.
Fairbanks, Morse & Co., Chicago, Ill.
Galion Iron Works & Manufacturing Co., Galion, O.
Good Roads Machinery Co., Kennett Square, Pa.
Port Huron Engine & Thresher Co., Port Huron, Mich.
Power & Mining Machinery Co., Cudahy, Wis.
Symons Bros. Co., Milwaukee, Wis.
Universal Crusher Co., Cedar Rapids, Mich.
Vulcan Iron Works, Wilkes-Barre, Pa.
Western Wheeled Scraper Co., Aurora, Ill.

DERRICKS.

American Hoist & Derrick Co., St. Paul, Minn.
Bond Co., Harold L., Boston, Mass.
Byers Machine Co., John F., Ravenna, O.
Carlin's Sons Co., Thos., Pittsburgh, Pa.
Chain Belt Co., Milwaukee, Wis.
Chicago Bridge & Iron Works, Chicago, Ill.
Clyde Iron Works, Duluth, Minn.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Dake Engine Co., Grand Haven, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Flory Manufacturing Co., S., Bangor, Pa.
Lidgerwood Manufacturing Co., New York, N. Y.
Manufacturers Supply Co., Minneapolis, Minn.
McMyler Interstate Co., Bedford, O.
Monighan Machine Co., Chicago, Ill.
National Equipment Co., Chicago, Ill.
National Hoisting Engine Co., Harrison, N. J.
Orton & Steinbrenner Co., Chicago, Ill.
Parker Hoist & Machine Co., Chicago, Ill.
Pittsburgh-Des Moines Bridge & Iron Works, Pittsburgh, Pa.
Taylor Portable Steel Derrick Co., Chicago, Ill.
Terry & Tench Co., New York, N. Y.
Union Elevator & Machine Co., Chicago, Ill.
Vulcan Iron Works, Chicago, Ill.
Williams Co., G. H., Cleveland, O.

DIVING APPARATUS.

Hale & Son, A. J., Boston, Mass.
Merrill-Stevens Engineering Co., Jacksonville, Fla.
Morse & Son, A. J., Boston, Mass.
Schrader & Son, A., New York, N. Y.

DREDGES.

Bay City Dredge Works, Bay City, Mich.
Bucyrus Co., Milwaukee, Wis.
Ellicott Machine Corporation, Baltimore, Md.
Marion Osgood Co., Marion, O.
Marion Steam Shovel Co., Marion, O.
Norbom Engineering Co., Philadelphia, Pa.

DRILLS—BLAST HOLE AND QUARRY.

American Well Works, Aurora, Ill.
Armstrong Manufacturing Co., Waterloo, Ia.
Cyclone Drill Works, Orrville, O.
Keystone Quarry Drill Co., Beaver Falls, Pa.
Loomis Machine Co., Tiffin, O.

DRILLS—CORE.

American Well Works, Aurora, Ill.
Cyclone Drill Works, Orrville, O.

Ingersoll-Rand Co., New York, N. Y.
Loomis Machine Co., Tiffin, O.
McKiernan-Terry Drill Co., New York, N. Y.
Sullivan Machinery Co., Chicago, Ill.

DRILLS—ROCK.

American Diamond Rock Drill Co., New York, N. Y.
Bullock Manufacturing Co., Chicago, Ill.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Rock Drill Co., Cleveland, O.
Diamond Drill & Machine Co., Birdsboro, Pa.
Howells Mining Drill Co., Plymouth, Pa.
Ingersoll-Rand Co., New York, N. Y.
Independent Pneumatic Tool Co., Chicago, Ill.
McKiernan-Terry Drill Co., New York, N. Y.
Milne & Co., New York, N. Y.
Mine & Smelter Supply Co., New York, N. Y.
New York Engineering Co., New York, N. Y.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Phillips Rock Drill Co., Philadelphia, Pa.
Standard Diamond Drill Co., Chicago, Ill.
Sullivan Machinery Co., Chicago, Ill.
Wood Drill Works, Paterson, N. J.

DYNAMITE; BLASTING POWDER.

Aetna Powder Co., Chicago, Ill.
Burton Powder Co., Pittsburgh, Pa.
Cameron Powder Manufacturing Co., Emporium, Pa.
Dittmar Powder Works, New York, N. Y.
Du Pont de Nemours Powder Co., E. I., Wilmington, Del.
Excelsior Powder Co., Kansas City, Mo.
Hall & Sons Co., Ellis, Knox, Pa.
Hancock Chemical Co., Dollar Bay, Mich.
Hercules Powder Co., Wilmington, Del.
Independent Powder Co., Joplin, Mo.
Independent Powder Co. of Missouri, Joplin, Mo.
Jefferson Powder Co., Birmingham, Ala.
Keystone National Powder Co., Emporium, Pa.
King Powder Co., Cincinnati, O.
McAbee Powder & Oil Co., G. R., Pittsburgh, Pa.
National Powder Co., New York, N. Y.
Potts Powder Co., New York, N. Y.
Rockdale Powder Co., York, Pa.
Texas Dynamite Co., Beaumont, Tex.

ENGINES—GAS, GASOLINE, KEROSENE AND OIL.

Affiliated Manufacturers Co., Milwaukee, Wis.
Armstrong Manufacturing Co., Waterloo, Ia.
Domestic Engine & Pump Co., Shippensburgh, Pa.
Dunning, W. D., Syracuse, N. Y.
Erie Pump & Engine Works, Erie, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
Flint & Walling Manufacturing Co., Kendallville, Ind.
Gray Motor Co., Detroit, Mich.
Heer Engine Co., Portsmouth, O.
Hersey Manufacturing Co., South Boston, Mass.
International Harvester Co., Chicago, Ill.
Lamb Boat & Engine Co., Clinton, Ia.
Mietz, August, New York, N. Y.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
National Meter Co., New York, N. Y.
National Transit Co., Oil City, Pa.
New Way Motor Co., Lansing, Mich.
Novo Engine Co., Lansing, Mich.
Original Gas Engine Co., Lansing, Mich.
Otto Gas Engine Works, Philadelphia, Pa.
Power & Mining Machinery Co., Cudahy, Wis.
Standard Scale & Supply Co., Pittsburgh, Pa.
Whitman Agricultural Co., St. Louis, Mo.

ENGINES—HOISTING.

Allis-Chalmers Co., Milwaukee, Wis.
American Clay Machinery Co., Bucyrus, O.
American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting Machinery Co., Cleveland, O.
Byers Co., John F., Ravenna, O.
Carlin's Sons Co., Thos., Pittsburgh, Pa.
Clyde Iron Works, Duluth, Minn.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Dake Engine Co., Grand Haven, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Domestic Engine & Pump Co., Shippensburgh, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
Flory Manufacturing Co., Bangor, Me.
Gade Excavating Co., Iowa Falls, Ia.
International Harvester Co., Chicago, Ill.
Koehring Machine Co., Milwaukee, Wis.
Lidgerwood Manufacturing Co., New York, N. Y.
Maine Electric Co., New York, N. Y.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Mundy, J. S., Newark, N. J.
National Hoisting Engine Co., Harrison, N. J.
Novo Engine Co., Lansing, Mich.
Original Gas Engine Co., Lansing, Mich.
Otto Gas Engine Works, Philadelphia, Pa.
Ransome Concrete Machinery Co., Dunellen, N. J.
Standard Scale & Supply Co., Pittsburgh, Pa.
Stroudsburg Engine Works, Stroudsburg, Pa.
Thomas Elevator Co., Chicago, Ill.

ENGINES—STEAM.

Allis-Chalmers Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
American Hoist & Derrick Co., St. Paul, Minn.
Ball Engine Co., Erie, Pa.
Buckeye Engine Co., Salem, O.
Clyde Iron Works, Duluth, Minn.
Cooper & Co., C. & G., Mt. Vernon, O.
Erie City Iron Works, Erie, Pa.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Griffith & Wedge Co., Zanesville, O.
Harris Steam Engine Co., Providence, R. I.
Harrisburg Foundry & Machine Works, Harrisburg, Pa.
Hewes & Phillips Iron Works, Newark, N. J.
Hooven-Owens-Rentschler Co., New York, N. Y.
Lawrence Engine Works, Lawrence, Mass.
Leffel & Co., James, Springfield, O.
McGowan Co., John H., Cincinnati, O.
McIntosh, Seymour & Co., Auburn, N. Y.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Murray Iron Works Co., Burlington, Ia.
Nordberg Manufacturing Co., Milwaukee, Wis.
Providence Engine Works, Providence, R. I.
Rollins Engine Co., Nashua, N. H.
Skinner Engine Works, Erie, Pa.
Sterling Machine Co., Norwich, Conn.
Sturtevant Co., B. F., Boston, Mass.
Vilter Manufacturing Co., Milwaukee, Wis.
Watts-Campbell Co., Newark, N. J.

FIRE EQUIPMENT.

Chemical Engines.

American La France Fire Engine Co., Elmira, N. Y.
Badger Fire Extinguisher Co., Boston, Mass.
Childs Co., Utica, N. Y.
Robinson Fire Apparatus Manufacturing Co., St. Louis, Mo.

Fire Extinguishers.

Badger Fire Extinguisher Co., Boston, Mass.
Massillon Iron & Steel Co., Massillon, O.
Pyrene Manufacturing Co., New York, N. Y.
Simmons Co., John, New York, N. Y.
Woodhouse Manufacturing Co., New York, N. Y.

Fire Hose.

Empire Rubber & Tire Co., Trenton, N. J.
Eureka Fire Hose Manufacturing Co., New York, N. Y.
Fabric Fire Hose Co., New York, N. Y.
Goodrich Co., B. F., Akron, O.
Gutta Percha & Rubber Manufacturing Co., Akron, O.
New York Belting & Packing Co., New York, N. Y.

Fire Hose Couplings, Expansion Rings and Nozzles.

Anderson Coupling & Fire Supply Co., Kansas City, Kas.
Boston Coupling Co., Boston, Mass.
Crane Co., Chicago, Ill.
Morse & Sons, Andrew J., Boston, Mass.

Fire Hose Racks.

Elkhart Brass Manufacturing Co., Elkhart, Ind.
Seagrave Co., Columbus, O.

FORGES—PORTABLE.

Beggs & Co., James M., Warren, N. Y.
Billings & Spencer Co., Hartford, Conn.
Boynton & Plummer, Worcester, Mass.
Brown & Patterson, Brooklyn, N. Y.
Buffalo Forge Co., Buffalo, N. Y.
Canedy-Otto Manufacturing Co., Chicago Heights, Ill.
Champion Blower & Forge Co., Lancaster, Pa.
Chicago Scale Co., Chicago, Ill.
Cleveland Steam Gauge Co., Cleveland, O.
Cox & Sons Co., Philadelphia, Pa.
Cummings, David, Chicago, Ill.
Fargo Foundry Co., Fargo, N. Dak.
Fate & Jones Co., Pittsburgh., Pa.
Hauck Manufacturing Co., New York, N. Y.
Potts, D. H., Lancaster, Pa.
Roots Co., P. H. & M. F., Connersville, Ind.
Silver Manufacturing Co., Salem, O.
Sturtevant Co., B. F., Boston, Mass.
Walsh & Jones, Harrison, N. J.

FORKS—STONE AND BALLAST.

American Fork & Hoe Co., Cleveland, O.
Bond Co., Harold L., Boston, Mass.
Fairbanks, Morse & Co., Chicago, Ill.
Union Fork & Hoe Co., Columbus, O.

FORMS—BUILDING.

American Bridge Co., New York, N. Y.
Blaw Steel Construction Co., Pittsburgh, Pa.
Mitchell-Tappen Co., Allentown, Pa.
Ransome Concrete Machinery Co., Dunellen, N. J.
Reichert Manufacturing Co., Milwaukee, Wis.
Traylor Engineering & Manufacturing Co., Milwaukee, Wis.

FORMS—ADJUSTABLE CLAMP.

Dayton Malleable Iron Works, Dayton, O.
Insley Manufacturing Co., Indianapolis, Ind.
Universal Form Clamp Co., Chicago, Ill.

FORMS—METAL.

American Bridge Co., New York, N. Y.
Blaw Steel Construction Co., Pittsburgh, Pa.
Foote Concrete Machinery Co., Nunda, N. Y.
Hotchkiss Lock Metal Form Co., Binghamton, N. Y.
Lennon Flume Co., Colorado Springs, Colo.
Traylor Engineering & Manufacturing Co., Allentown, Pa.

FURNACES AND KETTLES.

Acme Road Machinery Co., Frankfort, N. Y.
Biehl Iron Works, Reading, Pa.
Leadite Co., Philadelphia, Pa.
Littleford Bros., Cincinnati, O.
Macleod & Co., Walter, Cincinnati, O.
Riter-Conley Manufacturing Co., Leetsdale, Pa.
Rockwell Co., W. S., New York, N. Y.
Stuebner Iron Works, Long Island City, N. Y.
Union Iron Works, Hoboken, N. J.

GENERATORS AND MOTORS.

C. & C. Electric Manufacturing Co., Garwood, N. J.
DeLaval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago, Ill.
Fort Wayne Electric Co., Fort Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Otis Elevator Co., New York, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.
Western Electric Co., Chicago, Ill.
Westinghouse Electric Co., Pittsburgh, Pa.

GRADERS.

Acme Road Machinery Co., Frankfort, N. Y.
Austin Manufacturing Co., Chicago, Ill.
Austin Western Road Machinery Co., Aurora, Ill.
Baker Manufacturing Co., Springfield, Ill.
Buffalo Steam Roller Co., Buffalo, N. Y.
Case Threshing Machine Co., J. I., Racine, Wis.
Disk Grader & Plow Co., Minneapolis, Minn.
Galion Iron Works & Manufacturing Co., Galion, O.
Glide Road Machinery Co., Minneapolis, Minn.
Good Roads Machinery Co., Kennett Square, Pa.
Kelly-Springfield Road Roller Co., Springfield, O.
Kilbourne & Jacobs Manufacturing Co., Columbus, O.
Linder Grader Co., Matthews, Ind.
Ohio Road Machinery Co., The, Oberlin, O.
Russell Grader Manufacturing Co., Minneapolis, Minn.
Sidney Steel Scraper Co., Sidney, O.
Stroud Manufacturing Co., Omaha, Neb.
Universal Road Machinery Co., Kingston, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.

GRADERS—RAILROAD.

Jordan Co., O. F., Chicago, Ill.
Union Iron Works, Springfield, Mo.

HEATERS—PORTABLE, GRAVEL AND SAND.

American Clay Machinery Co., Bucyrus, O.
Barrett Manufacturing Co. (Asphalt), New York, N. Y.
Equitable Asphalt Maintenance Co. (Asphalt), Kansas City, Mo.
Honhorst Co., Jos. (Asphalt), Cincinnati, O.
Littleford Bros. (Asphalt), Cincinnati, O.
Ruggles-Coles Engineering Co., New York, N. Y.
Tidewater Iron Works Manufacturing Co., Hoboken, N. J.

HOISTS—CONCRETE.

Archer Iron Works, Chicago, Ill.
Insley Manufacturing Co., Indianapolis, Ind.
Lakewood Engineering Co., Cleveland, O.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Milwaukee Concrete Mixer Co., Milwaukee, Wis.
Ransome Concrete Machinery Co., Dunellen, N. J.
Wylie Co., J. S., Chicago, Ill.

HOISTS—ELECTRIC.

American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting Machinery Co., Cleveland, O.
Byers Co., John F., Ravenna, O.
Carlin's Sons Co., Thos., Pittsburgh, Pa.
Clyde Iron Works, Duluth, Minn.
Dake Engine Co., Grand Haven, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
English Iron Works, Kansas City, Mo.
Fairbanks, Morse & Co., Chicago, Ill.
Flory Manufacturing Co., S., Bangor, Pa.
General Electric Co., Schenectady, N. Y.
Jeffrey Manufacturing Co., Columbus, O.
Lidgerwood Manufacturing Co., New York, N. Y.
Maine Electric Co., Portland, Me.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Monighan Machine Co., Chicago, Ill.
Mundy, J. S., Newark, N. J.
National Hoisting Engine Co., Harrison, N. J.
Stroudsburg Engine Works, Stroudsburg, Pa.
Thomas Elevator Co., Chicago, Ill.

HOISTS—GASOLINE AND STEAM.

Allis-Chalmers Manufacturing Co., Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
Bates & Edmonds Motor Co., Lansing, Mich.
Byers Machine Co., John F., Ravenna, O.
Clyde Iron Works, Duluth, Minn.
Dake Engine Co., Grand Haven, Mich.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Domestic Engine & Pump Co., Shippenburg, Pa.
English Iron & Manufacturing Co., Kansas City, Mo.
Fairbanks, Morse & Co., Chicago, Ill.
Flory Manufacturing Co., S., Bangor, Pa.
Lidgerwood Manufacturing Co., New York, N. Y.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Milwaukee Concrete Mixer Co., Milwaukee, Wis.
Monighan Machine Co., Chicago, Ill.
National Hoisting Engine Co., Harrison, N. J.
Novo Engine Co., Lansing, Mich.
Power & Mining Machinery Co., Cudahy, Wis.
Ransome Concrete Machinery Co., Dunellen, N. J.
Smith Co., T. L., Milwaukee, Wis.
Standard Scale & Supply Co., Chicago, Ill.
Stroudsburg Engine Works, Stroudsburg, Pa.

HOISTS—HAND.

American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting Machinery Co., Cleveland, O.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Jeffrey Manufacturing Co., Columbus, O.
Marsh-Capron Manufacturing Co., Chicago, Ill.
Novo Engine Co., Lansing, Mich.
Thomas Elevator Co., Chicago, Ill.

HOISTS—PNEUMATIC.

Blake Manufacturing Co., Geo. F., New York, N. Y.
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compresser Works, New York, N. Y.

Curtis & Co., Manufacturing Co., St. Louis, Mo.
Dake Engine Co., Grand Haven, Mich.
Detroit Hoist & Machine Co., Detroit, Mich.
Ingersoll-Rand Co., New York, N. Y.
Knowles Steam Pump Co., New York, N. Y.
Northern Engine Works, Detroit, Mich.
Q. M. S. & Co. Vulcan Engineering, Chicago, Ill.
Ryerson & Son, Jos. T., Chicago, Ill.
Sullivan Machinery Co., Chicago, Ill.

HOPPERS.

Archer Iron Works, Chicago, Ill.
Insley Manufacturing Co., Indianapolis, Ind.
Littleford Bros, Cincinnati, O.
Mesker Bros. Iron Co., St. Louis, Mo.
Wylie Co., J. S., Chicago, Ill.

HOSE.

Boston Belting Co., Boston, Mass.
Diamond Rubber Co., Akron, O.
Edson Manufacturing Co., Boston, Mass.
Empire Rubber & Tire Co., East Trenton, N. J.
Goodrich Co., B. F., Akron, O.
Goodyear Rubber Co., Akron, O.
New York Belting & Packing Co., New York, N. Y.

HYDRAULIC MINING GIANTS.

Abendroth & Root Manufacturing Co., Newburgh, N. Y.
American Spiral Pipe Works., Chicago, Ill.
Hendy Iron Works, Joshua, San Francisco, Cal.

JACKS.

Anderson Forge & Machine Co., Detroit, Mich.
Duff Manufacturing Co., Pittsburgh, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
McKiernan-Terry Drill Co., New York, N. Y.
Watson-Stillman Co., New York, N. Y.

LIGHTS AND TORCHES.

Avery Portable Lighting Co., Milwaukee, Wis.
Dayton Malleable Iron Works, Dayton, O.
Kitson Hydro-Carbon Heating & Incandescent Co., Philadelphia, Pa.
McLeod Co., Walter, Cincinnati, O.
Milburn Co., Alex. A., Baltimore, Md.

LOCOMOTIVE CRANES.

American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting Machinery Co., Cleveland, O.
Browning Co., The, Cleveland, O.
Cleveland Crane & Engine Co., Wickliffe, O.
Exeter Machine Works, Pittsburgh, Pa.
Industrial Iron Works, Bay City, Mich.
Link-Belt Co., Chicago, Ill.
McMyler-Interstate Co., Bedford, O.
Maine Electric Co., Portland, Me.
Ohio Locomotive Crane Co., Bucyrus, O.
Orton & Steinbrenner Co., Chicago, Ill.

LOCOMOTIVES.

American Locomotive Co., New York, N. Y.
Atlas Car & Equipment Co., Cleveland, O.
Baldwin Locomotive Works, Philadelphia, Pa.
Davenport Locomotive Works, Davenport, Ia.

Lima Locomotive Works, Lima, O.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Porter Co., H. K., Pittsburgh, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.

PAINTS—METAL.

Anti-Stick Co., Westerville, O.
Barrett Manufacturing Co., New York, N. Y.
Carbolineum Wood Preserving Co., New York, N. Y.
Cheesman & Elliot, New York, N. Y.
Goheen Paint Co., Canton, O.
Lowe Bros, Dayton, O.
National Lead Co., Chicago, Ill.
Patterson-Sargent Co., Cleveland, O.
Republic Creosoting Co., Indianapolis, Ind.
Rinald Bros, Philadelphia, Pa.
Smooth-On Manufacturing Co., Jersey City, N. J.
Standard Paint Co., New York, N. Y.
Toch Bros., New York, N. Y.

PAVING EQUIPMENT.

Acme Road Machinery Co., Frankfort, N. Y.
Austin Manufacturing Co., Chicago, Ill.
Austin Western Road Machinery Co., Chicago, Ill.
Barrett Manufacturing Co., New York, N. Y.
Good Roads Machinery Co., Kennett Square, Pa.
Huber Manufacturing Co., Marion, O.
International Motor Co., New York, N. Y.
Kinney Manufacturing Co., Boston, Mass.
Littleford Bros., Cincinnati, O.
Lourie Manufacturing Co., Springfield, Ill.
Ohio Road Machinery Co., Oberlin, O.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Petrolithic Paving Co., Los Angeles, Cal.
Standard Manufacturing Co., Worcester, Mass.
Universal Road & Machinery Co., Kingston, N. Y.

PIER AND FOUNDATION PLANT.

Foundation Co., New York, N. Y.
Great Lakes Dredge & Dock Co., Cleveland, O.
McArthur Concrete Pile & Foundation Co., New York, N. Y.
Raymond Concrete Pile Co., New York and Chicago.
Underpinning & Foundation Co., New York, N. Y.

PILE DRIVERS.

American Hoist & Derrick Co., St. Paul, Minn.
Browning Co., Cleveland, O.
Bucyrus Co., Milwaukee, Wis.
Byers Machine Co., John F., Ravenna, O.
Carlin's Sons Co., Thos., Pittsburgh, Pa.
Clyde Iron Works, Duluth, Minn.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Edson Manufacturing Co., Boston, Mass.
Goubert, A. A., New York, N. Y.
Horton Construction Co., D. E., Buffalo, N. Y.
Industrial Works, Bay City, Mich.
Ingersoll-Rand Co., New York, N. Y.
Lidgerwood Manufacturing Co., New York, N. Y.
Link-Belt Co., Chicago, Ill.
McKiernan-Terry Drill Co., New York, N. Y.
McMyler Interstate Co., Bedford, O.
Maine Electric Co., Portland, Me.
Mundy, J. S., Newark, N. J.
National Equipment Co., Chicago, Ill.
Orton & Steinbrenner, Chicago, Ill.
Union Iron Works, Hoboken, N. J.
Vulcan Iron Works, Chicago, Ill.

PILES—CONCRETE.

Electric Welding Co., Pittsburgh, Pa.
Great Lakes Dredge & Dock Co., Cleveland, O.
McArthur Concrete Pile & Foundation Co., New York, N. Y.
Raymond Concrete Pile Co., New York and Chicago.
Underpinning & Foundation Co., New York, N. Y.

PILES—CREOSOTED WOOD.

American Bridge Co., New York, N. Y.
American Creosote Works, New Orleans, La.
Ayer & Lord, Chicago, Ill.
Barber Asphalt Paving Co., Philadelphia, Pa.
International Creosote & Construction Co., Galveston, Tex.
Jennison & Wright Co., Toledo, O.
National Lumber Co., Texarkana, Tex.
Republic Creosoting Co., Indianapolis, Ind.
Wyckoff Pipe & Creosoting Co., New York, N. Y.

PILES—STEEL.

Carnegie Steel Co., Pittsburgh, Pa.
Jones & Laughlin Steel Co., Pittsburgh, Pa.
Lackawanna Steel Co., Lackawanna, N. Y.
United States Steel Piling Co., Chicago, Ill.
Wemlinger Steel Piling Co., New York, N. Y.

PIPE—CAST IRON.

American Cast Iron Pipe Co., Birmingham, Ala.
Central Foundry Co., New York, N. Y.
U. S. Cast Iron Pipe & Foundry Co., Philadelphia, Pa.

PIPE COVERING.

Barrett Manufacturing Co., New York, N. Y.
Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York, N. Y.
New York Asbestos Manufacturing Co., New York, N. Y.
U. S. Mineral Wool Co., New York, N. Y.
Wyckoff & Son, A., Elmira, N. Y.

PIPE LINE TOOLS.

Duff Manufacturing Co., The, Pittsburgh, Pa.
Smith Manufacturing Co., A. P., East Orange, N. J.

PIPE—STEEL.

Abendroth & Root Manufacturing Co., New York, N. Y.
American Spiral Pipe Co., Chicago, Ill.
National Tube Co., Pittsburgh, Pa.
Standard Spiral Pipe Co., Chicago, Ill.

PIPE—WOOD STAVE.

Canal Lumber Co., Seattle, Wash.
Michigan Pipe Co., Bay City, Mich.
National Wood Pipe Co., Portland, Ore.
Pacific Coast Pipe Co., Seattle, Wash.
Pacific Pipe & Tank Co., Los Angeles, Cal.
Portland Wood Pipe Co., Portland, Ore.
Redwood Manufacturing Co., San Francisco, Cal.
Standard Wood Pipe Co., Williamsport, Pa.
Washington Pipe & Foundry Co., Tacoma, Wash.
Wyckoff & Son Co., Portland, Ore.
Wyckoff Pipe & Creosoting Co., New York, N. Y.

PIPE—WROUGHT IRON.

Abbe Engineering Co., New York, N. Y.
Byers Co., A. M., Pittsburgh, Pa.
Mark Manufacturing Co., Evanston, Ill.
National Tube Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Pa.

PLOWS.

Acme Road Machinery Co., Frankfort, N. Y.
Austin Manufacturing Co., Chicago, Ill.
Burch Plow Works, Crestline, O.
Case Threshing Machine Co., J. I., Racine, Wis.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Disc Grader & Plow Co., Minneapolis, Minn.
Dobbie Foundry & Machine Co., Niagara Falls, N. Y.
Good Roads Machinery Co., Kennett Square, Pa.
Kelly-Springfield Road Roller Co., Springfield, O.
Port Huron Engine & Thresher Co., Port Huron, Mich.
Russell Grader Manufacturing Co., Minneapolis, Minn.
Stroud Manufacturing Co., Omaha, Neb.
Western Wheeled Scraper Co., Aurora, Ill.
Wiard Plow Co., Buffalo, N. Y.

POST HOLE DIGGERS.

Oshkosh Manufacturing Co., Oshkosh, Wis.
Whitman & Barnes Manufacturing Co., Akron, O.

PUMPS.

(Key: Cent., Centrifugal; Cont., Contractors; D., Dredge; D. W., Deep Well; Dia., Diagram; S., Sand; Vac., Vacuum.)

Alberger Pump & Condenser Co. (Cent.), New York, N. Y.
Allis-Chalmers Co. (Cent.), Milwaukee, Wis.
American Well Works (D. W., Cent., S.), Aurora, Ill.
Bates & Edmonds Motor Co. (Trench, Dia.), Lansing, Mich.
Baker & Knowles Steam Pump Works (Cont., D. W.), East Cambridge, Mass.
Bond Co., Harold L. (Dia. Vac., S. D.), Boston, Mass.
Boston & Lockport Block Co. (Dia.), East Boston, Mass.
Cameron Steam Pump Co. (Cent., Cont., D. W., Trench, Dia.), New York, N. Y.
C. H. & E. Manufacturing Co. (Dia., Cont.), Milwaukee, Wis.
Cook Well Co. (D. W.) St. Louis, Mo.
Darling Pump & Manufacturing Co. (Cent.), Williamsport, Pa.
Dean Bros. Steam Pump Co. (D. W.), Indianapolis, Ind.
Deane Steam Pump Co. (Cont., D. W.), New York, N. Y.
DeLaval Steam Turbine Co. (Cent.), Trenton, N. J.
Deming Co. (Cent., D. W., Dia.), Salem, O.
Domestic Engine Pump Co. (Cent., Dia., Trench), Boston, Mass.
Edson Manufacturing Co. (Cont., Dia., Trench), Boston, Mass.
Elliott Machine Corporation (D., S.), Baltimore, Md.
Erie Pump & Engine Works (S., D.), Erie, Pa.
Fairbanks-Morse & Co. (D. W., Cent., Dia.), Chicago, Ill.
Goulds Manufacturing Co. (Cent., Cont., D. W., Dia.), Seneca Falls, N. Y.
Ingersoll-Rand, New York, N. Y.
Keystone Pump & Manufacturing Co. (D. W., S.), Beaver Falls, Pa.
Kingsford Foundry & Machine Co. (T., Cent., D. W.), Oswego, N. Y.
Laidlaw-Dunn-Gordan Co., Cincinnati, O.
Lawrence Machine Co. (Cent., D.), Lawrence, Mass.
Lawrence Pump & Engine Co. (Cent., D.), Lawrence, Mass.
McGowan Pump Co., John H. (Cent., Cont.), Cincinnati, O.
Morris Machine Works (Cent., D. S.), Baldwinsville, N. Y.
National Transit Co. (Cent., Cont., D. W.), Oil City, Pa.
Norbom Engineering Co. (D., S.), Philadelphia, Pa.
Nye Steam Pump Co. (Cont.), Chicago, Ill.
Original Gas Engine Co. (Dia., Cont), Lansing, Mich.
Oshkosh Manufacturing Co. (Trench, Cent., Dia.), Oshkosh, Wis.
Parker, A. A. (Dia., Cont.), Lansing, Mich.

Power & Mining Machinery Co., Cudahy, Wis.
Providence Engine Works (Cent.), Providence, R. I.
Pulsometer Steam Pump Co. (Cont.), New York, N. Y.
Standard Scale & Supply Co. (Trench, Dia., Cont.), Pittsburgh, Pa.
Van Wie Pump Co. (Cont., Cent., D. W., D., S., Dia.), Syracuse, N. Y.
Waterworks Equipment Co., New York, N. Y.
Watson-Stillman Co. (Cent.), New York, N. Y.
Whitman Agricultural Co. (Cent., Trench), St. Louis, Mo.
Wood & Co., R. D. (Cent.), Philadelphia, Pa.
Worthington, Henry R. (Cent.), New York, N. Y.

RAILS AND TRACK SUPPLIES.

Atlantic Equipment Co., Chicago, Ill.
Atlas Car & Manufacturing Co., Cleveland, O.
Cambria Steel Co., Johnstown, Pa.
Carnegie Steel Co., Pittsburgh, Pa.
Easton Car & Construction Co., Easton, Pa.
Hyman Michaels Co., Chicago, Ill.
Jones & Laughlin, Pittsburgh, Pa.
Kenly Co., W. K., Chicago, Ill.
Lackawanna Steel Co., Lackawanna, N. Y.
Lakewood Engineering Co., Cleveland, O.
Males Co., Cincinnati, O.
Orenstein-Arthur Koppel Co., Koppel, Pa.
Pennsylvania Steel Co., Steelton, Pa.
Union Iron Works, Hoboken, N. J.
United States Steel Co.,

REFRIGERATING AND ICE PLANT.

International Cooling Co., New York, N. Y.
Vilter Manufacturing Co., Milwaukee, Wis.
Walton & Son, Louisville, Ky.

RIVETERS—PNEUMATIC.

Chicago Pneumatic Tool Co., Chicago, Ill.
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
McKiernan-Terry Drill Co., New York, N. Y.
Niagara Devices Co., Buffalo, N. Y.
Sullivan Machinery Co., Chicago, Ill.

ROLLERS—ROAD.

Acme Road Machinery Co., Frankfort, N. Y.
Austin Manufacturing Co., Chicago, Ill.
Austin Western Road Machinery Co., Chicago, Ill.
Baker Manufacturing Co., Springfield, Ill.
Buffalo Pitts Co., Buffalo, N. Y.
Buffalo Steam Roller Co., Buffalo, N. Y.
Erie Machine Shops, Erie, Pa.
Galion Iron Works, Galion, O.
Glide Road Machinery Co., Minneapolis, Minn.
Good Roads Machinery Co., Kennett Square, Pa.
Huber Manufacturing Co., Marion, O.
Kelly-Springfield Road Roller Co., Springfield, O.
Ohio Road Machinery Co., Oberlin, O.
Russell Grader Manufacturing Co., Minneapolis, Minn.
Universal Road Machinery Co., Kingston, N. Y.
Vulcan Iron Works, Wilkes-Barre, Pa.
Western Wheeled Scraper Co., Aurora, Ill.

ROPE—WIRE.

American Manufacturing Co., New York, N. Y.
American Steel & Wire Co., Chicago, Ill.
Broderick & Bascom Rope Co., St. Louis, Mo.
Leschen & Sons Rope Co., A., St. Louis, Mo.
Roebling's Sons Co., John A., Trenton, N. J.

St. Louis Cordage Co., St. Louis, Mo.
Trenton Iron Co., Trenton, N. J.
Waterbury Co., New York, N. Y.

SAND BLAST MACHINES.

Ingersoll-Rand Co., New York, N. Y.
Laidlaw-Dunn-Gordan, Cincinnati, O.
Niagara Devices Co., Buffalo, N. Y.

SAW RIGS—PORTABLE.

American Wood Working Machinery Co.,
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago, Ill.
Kansas City Engine Works, Kansas City, Mo.
Oshkosh Manufacturing Co., Oshkosh, Wis.
Smith, Geo. D., Chicago, Ill.
Stover Engine Works, Chicago, Ill.
Whitman Agricultural Co., St. Louis, Mo.

SCALES.

Avery Scale Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago, Ill.
Smith Co., T. L., Milwaukee, Wis.
Standard Scale & Supply Co., Pittsburgh, Pa.

SCRAPERS.

American Steel Scraper Co., Sidney, O.
Austin Manufacturing Co., Chicago, Ill.
Austin Western Road Machinery Co., Chicago, Ill.
Baker Manufacturing Co., Springfield, O.
Fairbanks, Morse & Co., Chicago, Ill.
Galion Iron Works, Galion, O.
Glide Road Machinery Co., Minneapolis, Minn.
Good Roads Machinery Co., Kennett Square, Pa.
Kilbourne & Jacobs, Columbus, O.
Oberlin Road Machinery Co., Oberlin, O.
Russell Grader Manufacturing Co., Minneapolis, Minn.
Sidney Steel Scraper Co., Sidney, O.
Stroud Manufacturing Co., Omaha, Neb.
Universal Road Machinery Co., Kingston, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.
Zieg Manufacturing Co., F. B., Frederickstown, O.

SCREENS—SAND, GRAVEL AND BROKEN STONE.

Austin Manufacturing Co., Chicago, Ill.
Buchanan Co., C. G., New York, N. Y.
Clinton Wire Cloth Co., Clinton, Mass.
Dull Co., Raymond W., hicago, Ill.
Good Roads Machinery Co., Kennett Square, Pa.
Jeffrey Manufacturing Co., Columbus, O.
Power & Mining Machinery Co., Cudahy, Wis.
Raymond Bros. Impact Pulverizer Co., Chicago, Ill.
Sackett Screen & Chute Co., Chicago, Ill.
Smith Co., T. L., Milwaukee, Wis.
Stephens-Adamson Co., Aurora, Ill.
Union Iron Works, Hoboken, N. J.
Weller Manufacturing Co., Chicago, Ill.

SHOVELS—STEAM.

American Clay Machine Co., Bucyrus, O.
Browning Steam Shovel Co., Cleveland, O.
Bucyrus Co., South Milwaukee, Wis.
Marion-Osgood Co., Marion, O.
Marion Steam Shovel Co., Marion, O.
Thew Automatic Shovel Co., Lorain, O.

SKIPS.

Bartlett & Snow Co., Cleveland, O.
Contractors Plant Manufacturing Co., Buffalo, N. Y.
Insley Manufacturing Co., Indianapolis, Ind.
Lakewood Engineering Co., Cleveland, O.
Otis Elevator Co., New York, N. Y.
Ransome Concrete Machinery Co., Dunellen, N. J.
Stuebner Iron Works, G. L., Long Island City, N. Y.
Union Iron Works, San Francisco, Cal.

SPRINKLING WAGONS AND CARTS.

Acme Road Machinery Co., Frankfort, N. Y.
Austin Manufacturing Co., Chicago, Ill.
Austin Western Road Machinery Co., Chicago, Ill.
Galion Iron Works, Galion, O.
Good Roads Machinery Co., Kennett Square, O.
Kelley-Springfield Road Roller Co., Springfield, O.
Littleford Bros., Cincinnati, O.
Milburn Wagon Co., Toledo, O.
Port Huron Engine & Thresher Co., Port Huron, Mich.
Studebaker Corporation, South Bend, Ind.
Tiffin Wagon Works, Tiffin, O.
Universal Road Machinery Co., Kingston, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.
Winkle Bros., South Bend, Ind.

STUCCO MACHINES.

Bartlett & Snow Co., C. O., Cleveland, O.
McDonnell Boiler & Iron Works, Des Moines, Ia.
Swenson Auto-Stucco Machinery Co., Port Chester, N. Y.

STUMP PULLERS.

Ammond Stump Machine Co., Cedar Springs, Mich.
Bennet Co., H. L., Westerville, O.
Butterworth & Lowe, Grand Rapids, Mich.
Clyde Iron Works, Duluth, Minn.
Edwards, C. D., Albert Lea, Minn.
Farquhar Co., A. B., York, Pa.
Hercules Manufacturing Co., Centerville, Pa.
Little Giant Stump Puller Co., Hattiesburg, Miss.
Milne Manufacturing Co., Monmouth, Ill.
National Iron Co., Duluth, Minn.
Zimmerman Steel Co., Lone Tree, Ia.

SURVEYORS' AND ENGINEERS' INSTRUMENTS, ETC.

Aloe Co., A. S., St. Louis, Mo.
Ainsworth & Son, Wm., Denver, Colo.
Architects & Engineers Supply Co., Kansas City, Mo.
Bausch & Lomb Optical Co., Rochester, N. Y.
Beckman Co., L., Toledo, O.
Berger & Sons, C. L., Boston, Mass.
Brandis & Sons Manufacturing Co., Brooklyn, N. Y.
Buff & Buff Manufacturing Co., Boston, Mass.
Dietzgen, Eugene, Co., Chicago, Ill.
Elliott Co., B. K., Pittsburgh, Pa.
Fink Instrument Co., F. B., St. Louis, Mo.
Gurley, W. & L. E., Troy, N. Y.
Hanna Manufacturing Co., Troy, N. Y.
Heller & Brightly, Philadelphia, Pa.
Iszard-Warren Co., Philadelphia, Pa.
Keuffel & Esser Co., New York, N. Y.
Lietz Co., A., San Francisco, Cal.
Pease Co., C. F., Chicago, Ill.
Ross, Louis, San Francisco, Cal.
Seelig & Sons, Chicago, Ill.
Technical Supply Co., Scranton, Pa.

Warren-Knight Co., Philadelphia, Pa.
Weber & Co., F., Philadelphia, Pa.
Young & Son, Philadelphia, Pa.

TAMPERS—POWER.

Pawling & Harnischfeger Co., Milwaukee, Wis.
Lourie Manufacturing Co., Springfield, Ill.

TELEPHONES—DISPATCHING SYSTEMS AND EQUIPMENT.

Garford Electric Co., Elyria, O.
Stromberg-Carlson Telephone Manufacturing Co., Rochester, N. Y.
Western Electric Co., Chicago, Ill.

TENTS AND CAMPING EQUIPMENT.

American Tent & Awning Co., Minneapolis, Minn.
Ames Harris-Neville, San Francisco, Cal.
Baker & Lockwood Manufacturing Co., Kansas City, Mo.
Buckeye Tent & Awning Co., Minneapolis, Minn.
Carnie Goudie Manufacturing Co., Kansas City, Mo.
Carpenter Co., Geo. B., Chicago, Ill.
Channon Co., H., Chicago, Ill.
Des Moines Tent & Awning Co., Des Moines, Ia.
Eberhardt & Co., Indianapolis, Ind.

TRACTION ENGINES.

Aultman-Taylor Co., Mansfield, O.
Avery Co., Peoria, Ill.
Buffalo Pitts Co., Buffalo, N. Y.
Case Threshing Machine Co., J. I., Racine, Wis.
Emerson Brantingham Co., Rockford, Ill.
Enterprise Machine Co., Minneapolis, Minn.
Fairbanks Morse & Co., Chicago, Ill.
Frick Co., Waynesboro, Pa.
Heer Engine Co., Portsmouth, O.
Holt-Caterpillar Co., Peoria, Ill.
Huber Manufacturing Co., Marion, O.
International Harvester Co., Chicago, Ill.
Ohio Tractor Sales Co., Columbus, O.
Pioneer Tractor Manufacturing Co., Winona, Minn.
Port Huron Engine & Thresher Co., Port Huron, Mich.
Rumely Co., M., La Porte, Ind.
Russell & Co., Massillon, O.
Wallace Tractor Co., Cleveland, O.

TRENCH BRACES.

Bottomley Machine Co., Alliance, O.
Dixon & Son, Chas. E., Pittsburg, Pa.
Duff Manufacturing Co., Pittsburg, Pa.
Kalamazoo Foundry & Machine Co., Kalamazoo, Mich.
Rolf-Martin Co., Ft. Wayne, Ind.
Union Elevator & Machine Co., Chicago, Ill.

TRENCHING MACHINES.

Austin Drainage Excavator Co., F. C., Chicago, Ill.
Buckeye Traction Ditcher Co., Findlay, O.
Carson Trench Machine Co., Boston, Mass.
Gade Excavating Co., Iowa Falls, Ia.
Heggie, Wm., Co., Joliet, Ill.
Parsons Co., G. W., Newton, Ia.
Pawling & Harnischfeger Co., Milwaukee, Wis.
Potter Manufacturing Co., Indianapolis, Ind.

WAGONS.

Acme Road Machinery Co., Frankfort, N. Y.
Acme Wagon Co., Emigsville, Pa.
Auburn Wagon Co., Martinsburg, W. Va.
Austin Manufacturing Co., Chicago, Ill.
Bain Wagon Co., Kenosha, Wis.
Beckert, Wm., Pittsburg, Pa.
Blake & Son, J. M., Buffalo, N. Y.
Buffalo Pitts Co., Buffalo, N. Y.
Buffalo Steam Roller Co., Buffalo, N. Y.
Columbia Wagon Co., Columbia, Pa.
Eagle Wagon Works, Auburn, N. Y.
Everett Manufacturing Co., Newark, N. J.
Galion Iron Works, Galion, O.
Glen Wagon Co., Seneca Falls, N. Y.
Good Roads Machinery Co., Kennett Square, Pa.
Haywood Wagon Co., Newark, N. J.
Huber Manufacturing Co., Marion, O.
Kentucky Wagon Co., Louisville, Ky.
Milburn Wagon Co., Toledo, O.
Port Huron Engine & Thresher Co., Port Huron, Mich.
Russell Grader Manufacturing Co., Minneapolis, Minn.
Schuttler Co., Peter, Chicago, Ill.
Smith & Sons, Manufacturing Co.. Kansas City, Mo
Streich, A., & Bros., Oshkosh, Wis.
Streich, Gabriel, Oshkosh, Wis.
Stroud Manufacturing Co., T. F., Omaha, Neb.
Studebaker Corporation, South Bend, Ind.
Troy Wagon Works Co., Troy, O.
Universal Road Machinery Co., Kingston, N. Y.
Watson Wagon Co., Canastota, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.
Winona Wagon Co., Winona, Minn.

WELDING MACHINES.

Davis-Bouronville Co., Jersey City, N. J.
Electric Welding Co., Pittsburg, Pa.
Milburn Co., Alex. P., Baltimore, Md.
Oxweld Acetylene Co., Chicago, Ill.

WHEELBARROWS.

Archer Iron Works, Chicago, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Kilbourne & Jacobs, Columbus, O.
Lansing Co., Lansing, Mich.
Miller & Coulson, Pittsburg, Pa.
Smith Co., T. L., Milwaukee, Wis.
Sterling Wheelbarrow Co., Milwaukee, Wis.

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